THESIS FOR THE DEGREE OF DOCTOR OF PHILOSOPHY

Managing Knowledge in Professional Service Organizations

Technical Consultants Serving the Construction Industry

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Abstract

Professional service organizations refine, package and sell knowledge. The aim of the present investigation is to create an understanding of how technical consultancy firms serving the construction industry manage knowledge. Sub-processes of knowledge transfer: acquisition, distribution, making meaning, organizational memory and retrieval are integrated in business service processes of such firms. Six enablers for learning and knowledge transfer were identified: organizational structure, communication and the monitoring of strategy, process, culture, systems for training and learning, and technology. Four Swedish construction consultancy groups with between 800 and 2,300 employees each were selected. Within each of these, one or more departments were surveyed in 1997-98 and again in 2000 using questionnaires and semi-structured interviews. Results were obtained in part by factor analysis of responses. Respondents consider market knowledge and project knowledge to be crucial, the former being stored mostly in the heads of people and the latter in several ways. While managers confirmed the existence of strategies for knowledge management, these remained largely unknown to employees, and no particular manager was identified as responsible for all knowledge management efforts. There was evidence of a shared business vision, but knowledge management tended to occur on the departmental level. Socialization in daily work, talking to colleagues in the department, was the dominating method for creating and transferring knowledge. Proximity to sources and informal media were preferred by respondents. Most IT tools in use were basic and related to design tasks, whereas tools enabling virtual meetings and knowledge combination had not been implemented. Reported obstacles to knowledge transfer include lack of time, lack of rewards for sharing knowledge and shortage of funding. Strong relations on the individual level were found between communicative problem solving, high functional position in the department and choice of traditional media. Age of consultants was found to influence knowledge transfer. Suggested implications for managers include translating business strategy into knowledge strategy, clarifying responsibility for knowledge management, supporting stronger intraorganizational interpersonal networks and improving career paths for younger consultants.

Keywords: knowledge management, construction, consultants

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Preface

The research presented in this dissertation started at what was then the Department for Construction Management and Economics at Chalmers University of Technology in 1996, and was completed at the Department for Service Management. The two studies, referred to as the first study (1997-98) and the second study (2000), have both been funded by the Swedish Council for Building Research and the four groups of construction technical consultancy companies that have participated: Jacobson & Widmark, Kjessler & Mannerstråle, Scandiaconsult and SWECO. In the final stages of the project, the Development Fund of the Swedish Construction Industry (SBUF) contributed financial support through the Centre for Management of the Built Environment (CMB) at Chalmers University of Technology.

It would not have been possible for me to write this dissertation without the invaluable insights, support, and comfort provided by colleagues and friends. In addition, they have helped me to keep a healthy distance to my research endeavours. The list is long, but there are some people to whom I would like to express my explicit and sincere gratitude.

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My English has been skilfully corrected by Linda Schenck. I also wish to express my appreciation to Ramin Oftadeh and Christer Sfeir, who helped me with editing the manuscript during the final phase, as well as several colleagues and friends who read chapters of the final draft in proof.

In the preface to my licentiate thesis, I compared research to a journey to foreign countries with new languages. This particular journey has come to an end, although it will offer me only a temporary pause. Before continuing I wish to thank my wonderful family, Annette and Matilda, for their support, understanding and endurance.

Göteborg, November 2000

Per-Olof M. Sverlinger

1 Introduction to the research field

1.1 The rise of construction consultants

In his autobiography from 1929, J.G. Richert looked back at his time as a Göteborg municipal chief engineer, during the last decade of the nineteenth century. Although he was a public employee, he received several private commissions, and he noted that there was often scepticism about whether a publicly employed engineer should be allowed to perform consultancy work. He acknowledged that there is no doubt that such a liberty can be abused, whereas he saw it as self-evident that anyone entrusted with investigating, planning and designing can receive external impulses that may benefit his employer. In particular, the extensive hydrological investigations that preceded his proposals for water supply, would hardly have been able to be carried out if he had not had the experience of managing similar works in Malmö, according to Richert. Another commission he saw as being of great importance for his career was to write his expert opinion in a water court case in Lilla Edet. He invested a great deal of effort in it, and it was followed by further commissions within the hydropower field. However, the consequence of this twin workload was that he began to yearn for greater liberty, and at the end of 1896 he left his post to set up as a consulting engineer in Stockholm.

Richert was not the first person to do this, nor was he an exception. But the company he founded, Vattenbyggnadsbyrån (VBB), would merge in 1990 with Viak to form the largest Swedish group of construction engineers and architects. In 1997 they merged with FFNS, and now number more than 2,300 employees, of whom about 45 per cent can be regarded as professionals with an academic degree (SWECO, 1999). What men like Richert did (they were always men) was to take advantage of transformations in society and of technology change. But what were the driving forces for business creation at the time the first technical consultant firms started to grow?

Consulting engineers had long existed. The first European civil engineer known by name is Eupalinos, from Megara, who led the work at the aqueduct of the ancient city of Samos. Its construction began in about 550 B.C. (Sandström, 1970). Shipley (1987) speculates as how Eupalinos gained his technical knowledge through earlier projects. Eupalinos was clearly a consultant and was followed by many others, but they all had in common that they were employed by the client for realizing one project at the time, which sometimes took years. The new phenomenon at the end of the nineteenth century was that engineers started firms with many other well-educated

engineers working as independent consultants for many clients with many parallel projects in progress.

The first consulting engineers in the modern sense of the word appeared in the construction industry during the 1830s. They were experts, skilled and experienced through practice. It was their knowledge that gave them strength, not status from their military rank or their position as government officials. Their most important business assets were their knowledge and know-how about the physical infrastructure of society (Widegren, 1988, p. 21).

As a result of urban growth in nineteenth century Europe, owing to industrialization, it become common with large buildings in stone, many with central heating, running water, drains, and electricity or gas installations (Hult, 1989, p 218-219). The use of such facilities both in industry and in homes started a growing demand for media such as electrical power, fresh water, gas and coal as well as for infrastructure for transports. Creating this infrastructure required efforts from civil engineers, and conditions for coordination and standardization of materials and designs were good as government activities, such as the Swedish State Railways in Sweden, came to dominate in their respective markets. At the turn of the century, hydroelectric power had passed steampower as producer of electricity in Sweden. The three-phase current generator and long distance transfer of electrical power, invented around 1890 by Jonas Wenström among others, were necessary for the extension of hydroelectric power. This opened a period of river dam projects, which also provided jobs for civil engineers.

At the same time, a growing need for independent engineers emerged in the Swedish manufacturing industry. Manufacturers needed advice regarding investments in new technical equipment for their factories. Equipment manufacturers and suppliers had their engineers but many of their customers wanted independent advice and to be in control of the installations. Ångpanneföreningen (ÅF), The Swedish Steam Boiler Society, was founded as an association for mechanical engineers specialized in inspection and control of steam-boilers. The need for civil engineers also grew owing to the construction of new and larger harbours and docks. New technology made it possible to produce steel inexpensively in large quantities and then use it to build new and larger ships powered by steam (Dillard, 1967, p. 310). The increased use of iron and the requirements for industrial buildings separated the professions of architects and engineers (Bowley, 1966, pp. 347). The main revolution in methods of building took place in industrial and commercial works where technical function rather than appearance was regarded as the primary problem. Architects became technically dependent on engineers, while engineers were not dependent on architects (Bowley, 1966, pp. 346-347). Education of engineers was well established in Sweden and most of

Europe in the late nineteenth century (Hult, 1989, pp. 260-262). The supply of engineers had now achieved a critical mass and scientific specialized knowledge and methods were of much help in improving both the design and construction processes and the products. The use of qualified employees is still an essential asset for technical consultant firms today. Their ability to manipulate and refine existing knowledge in order to solve specific client problems is what creates the output of firms in this industry.

At the time Richert founded his own business there were thus several factors that explain why it was particularly favourable to start a technical consultancy company. We will never know exactly what drove Richert to set up his own company. It might have been, as Maister (1982) asserts, that professional service firms are often driven by the search for professionally challenging work, rather than economic gain, following from larger market share or higher profitability. Professional knowledge can be a goal in itself for the individual.

However, at the end of the nineteenth century, there seems to have been little or no discussion of knowledge as such in the professional circles where Richert moved. Today, knowledge, and how it should be managed, is a hot topic for technical consultants.

1.2 The use of the term "knowledge" in the language of technical consultants

Swedish technical consultants use the concept of knowledge in a broad sense when they describe their activities and culture in annual reports and similar documents. Usually consultants include theoretical knowledge, practical knowledge as well as experience and skills in their definition and use of the term knowledge.

> KM systematically employs its accumulated knowledge and experience to achieve superior productivity and creativity. (KM, 2000, p. 8)

It also seems to be a common opinion that knowledge can be stored in computer based systems and that it is possible for other employees to retrieve knowledge from such systems.

> SWECO's development into a customer-driven and future-oriented knowledge company – where knowledge is systematically gathered, structured and made accessible to the entire organization at all times – reduces dependency on individual employees. (SWECO, 2000, p. 39)

> A modern IT platform is under development and incorporates systems for preserving, sharing and recycling the knowledge possessed by the company's employees. (SCC, 2000, p. 10)

> New knowledge is also generated in consulting assignments through day-to-day teamwork between employees with complementary competencies. ….. SWECO's knowledge bank, the intranet, was..…. (SWECO, 2000, pp. 14-15)

Other words such as technical expertise are used interchangeably with knowledge when talking about employees who possess knowledge about methods, processes and technology used to complete tasks. In this chapter "knowledge" is used similarly to the way in which technical consultants use it, while a further discussion of the concept can be found in Chapter 2.

1.3 The importance of knowledge in a growing service sector

The development of production and employment during the last decades of the twentieth century has often been described as a service revolution of the same type as the agricultural revolution and the industrial revolution. Manufacturing declined in importance in all leading economies (Hoxley, 1998; Desmet and van Dierdonck, 1998, p. 47) and work increasingly involves the processing and production of symbols rather than physical materials (Cooper, Argyris, 1998, p. 351). Desmet and van Dierdonck (1998, p. 49) identify two groups of factors that play a central part in service sector growth. The first group is increasing consumer incomes and sociological change, which have led to greater demand for services. The second and more interesting group for this investigation is increased professionalism in organizations and technological change that have brought about the creation of new services, notably of producer services, such as engineering. Grönroos (2000, p. 46) has formulated a widely accepted definition of the service concept:

> A service is a process consisting of a series of more or less intangible activities that normally, but not necessarily always, take place in interactions between the customer and service employees and/or physical resources or goods and/or systems of the service provider, which are provided as solutions to customer problems.

This definition, although it might be thought to lack precision, fits well into the subject of this investigation and is useful because it focuses intangibility and solutions to customer problems as an output of the service process. Many service producers depend heavily on the knowledge of their employees. Adam Smith (1776) in his analysis of the division of labour, was early to refer to philosophers or men of speculation who make improvements in machinery. Fritz Machlup is said to have been the first modern economist to analyse knowledge related issues. In his book *The Production and Distribution of Knowledge in the United States*, he used a very generous definition of the knowledge industry, a term of his invention, and estimated that knowledge production was almost 29 per cent of adjusted GNP in 1958 (Machlup, 1962). Peter Drucker was quick to contend that knowledge had become the foundation of

the modern economy as we have shifted, in his view, from an economy of goods to a knowledge economy (Drucker, 1969, pp. 247, 249). Many authors have more recently claimed a paradigm shift and a new era in society, using labels such as the information society (Masuda, 1980), the third wave (Toffler, 1980), the knowledge society (Masuda, 1980 and Naisbitt, 1982), and the post-capitalist society (Drucker, 1993). All of these highlight knowledge.

Owing to the presence of increased professionalism in firms and the technological change pointed out by Grönroos (2000), knowledge can be considered a primary resource for organizations (Drucker, 1988a; OECD, 1999) and a source of wealth and competitive advantage for companies (Drucker, 1994; Zack, 1999) as well as nations (Porter, 1990). According to Drucker (1993), who had coined the terms “knowledge work” and “knowledge workers” around 1960, knowledge workers play a central role in the modern economy. The success of firms will ultimately depend on the competence of their professionals, relative to that of their counterparts in rival firms (Sveiby and Lloyd, 1987). With a revolution in services, the focus moves from mass production to a focus on individuals and their time available to serve. Perhaps the focus on the individual may not be as strong as in the age of the Swedish guild system, which was abandoned in 1846 (Hult, 1989, p. 221) as new communication technology had abolished local restrictions on the market (Hult, 1989, p. 152). Perhaps a new change in market restrictions and environmental conditions is now taking place, once again as the telecommunications sector and other infrastructure sectors have recently being deregulated, not only in Sweden but in many other countries as well.

It can be assumed that most organizations face a future in which knowledge supports competitive strength. This is not unique to the service sector, but for services and particularly professional services, it has long been reality. By making knowledge more easily available new communications technology such as that based on the web can change business rules just as fast as or faster than the telegraph and trains did in the later part of the nineteenth century. This change of business rules can be applied to a number of service industries that, in a broader sense, are based on managing knowledge. Such industries, as listed by Nachum (1998), include those that offer accounting and bookkeeping services, data processing and computer programming, advertising and marketing research, business and management consultancy, engineering and architectural services, and legal services. One sector with a long history, and which is focused on in this investigation, is the technical consultancy sector, serving the construction industry.

1.4 Professional services production in the Swedish construction industry

What is special about the Swedish sector of technical consultants serving the construction industry? Concerning the role of knowledge, there are several issues that must be pointed out before knowledge management can be discussed. The market for technical consultants and the market for a professional workforce have to be discussed, as well as the structure of owners and how business cycles affect the demand for specialized knowledge. Information technology in construction is also assumed to influence the work of technical consultants, as is technology change.

1.4.1 The market for Swedish architectural and technical consultants

The Swedish architectural and technical consulting industry consisted in 1998 of approximately 5,000 firms with combined sales of around SEK 17.5 (16.3) billion (AI, 1999). Four groups - SWECO, Ångpanneföreningen (ÅF), Scandiaconsult (SCC) and Jacobson & Widmark (J&W) - account for 30 per cent of the combined sales (AI, 1999; SWECO, 1999). The largest groups are presented in Table 1.1. Most of the sales volumes are generated by work in construction projects. Civil, structural and environmental engineering account for 30 per cent of the turnover of the industry, including 6 per cent from project management operations. Industrial engineering accounts for 30 per cent, and architectural operations account for 19 per cent. Heating, ventilation and sanitation account for 11 per cent, and energy and electricity for 10 per cent (AI, 1999).

Table 1.1 The largest architectural and technical consultancy groups in Sweden in 1997 and 1999 (AI, 1999 and 1999 annual report for each respective company).

	1997				1999			
Rank	Group	Spec.	Turnover (MSEK)	Average no. of employees	Group	Spec.	Turnover (MSEK)	Average no. of employees
1	SWECO	MD	1588	2354	SWECO	MD	1631	2154
2	SCC	MD	1262	1920	ÅF group	IEMEnr	1612	2222
3	ÅF group	IEMEnr	1170	1764	SCC	MD	1445	1935
4	J&W	MD	927	1435	Sigma	IIT	899	1096
5	Sigma	IIT	590	701	Semcon	I	864	1173
6	KM	MD	506	817	J&W	MD	808	1119
7	Semcon	I	496	695	KM	MD	669	963
8	Sycon	MD	495	695	Sycon	MD	549	819

MD (Multi Disciplinary), I (Industrial), M (Mechanical/HVAC), E (Electrical, Enr (Energy), IT (Information Technology)

There is no overall market leader in the Swedish market for architectural and technical consultants. Instead, specialized sub-markets have to be analysed. There are three major players in the market for architectural services: SWECO, White and Tema (AI, 1999). Similarly, in the market for structural engineering there are SWECO, J&W, SCC and KM. The building services market can be divided into two segments: heating, ventilation and sanitation

with market leading SWECO, ÅF and J&W and the electrical and telecom segment with J&W, SCC and Rejlers (AI, 1999). Hifab is the market leader in the sub-market for project management followed by SWECO and J&W. In the sub-market for water and environmental consultant services SWECO, KM and VIA VA-Project are the largest firms. SWECO and SwedPower are competitors in the market for hydropower as well as in the market for electrical and heating systems together with ÅF and Sycon. The market for land use, roads and railways are dominated by J&W, KM, SCC, SWECO, Tyréns, and Vägverket Konsult. When it comes to advanced civil engineering the strong competitors are J&W, KM, SCC, SWECO and ELU Konsult. The last sub-market is industrial engineering with Sigma, Semcon, ÅF and SWECO as the most important companies (AI, 1999). The absence of a single market leader and benchmark for the industry is emphasized by SCC (2000) in the annual report. However, after the J&W acquisition of KM in July 2000 (J&W, 2000b) the issue of market leadership might change.

Consultants mostly sell their services to clients, mostly property owners, but design-and-build contractors are also important buyers of services. A smaller proportion of total sales is accounted for by suppliers of materials, components and construction equipment. The management of built facilities creates further tasks for consultants in this field. Contractors, consultants, suppliers and manufacturers try to corner for themselves larger pieces of projects by developing extended services manifested in new organizational and contractual forms.

Two important changes in industry trends were noted in 1998 (SWECO, 1999). First an increase in clients' investments and second (and more interestingly) an increasing demand for services with higher engineering and technology content. These changes were further emphasized in 1999 by J&W (2000a), who concluded that competition and price pressure would further increase for assignments of a more routine nature and that there would be an increased demand for specialized services requiring specialized knowledge.

Concentrating on technical consultancy serving the construction industry and leaving architects aside, it can be asserted that the market for technical consultant services is characterized by price competition (usually bids with fixed prices) and low product differentiation. Entrance barriers are low, especially for small assignments, and new kinds of organizations such as staff providers and management consultants compete for some assignments. Many of the large technical consultant firms are therefore trying to move their services in the direction of a more advanced technological content, specialization and services that clearly add value for the customer. The technical consultants appear to respond to this competition by accelerating

their development as professional service organizations, something which increases cooperation with customers, suppliers and manufacturers.

> We know that our customers have a greater need for effective and innovative total solutions than for delivery of isolated services, which generally require elaborate coordination and often lead to quality defects and suboptimization. (SCC, 1999, p. 4)

The larger firms have recently begun to emphasize the advantage of their large number of people with considerable experience and the ability to coordinate that knowledge and experience.

> KM's corporate culture is characterized by dynamism, constant challenge and opportunity for professional growth. Each employee must have access to the accumulated knowledge of the entire company. …..... In order to circulate information and expertise among our employees, we are constructing networks and databases that will be available to everyone. At the same time, our customers will gain the ability to take advantage of accumulated experience and discover which employees have been involved in similar projects earlier, which will facilitate the coordination of various skills. .... We speak of offering our customers a brain chain. (KM, 2000, p. 3)

It is foreseen that technical solutions for customized designs will be developed in cooperation between the consulting engineer and the manufacturer, and some of the detailed design work will be transferred to the manufacturer. Similarly emphasis will be put on sustainable and easy-to-produce designs that should be designed in accordance also with new environmental requirements.

Contractors, on the other hand, threaten the consultants by influencing the early stages of construction projects. Alternatively, they want to manage the whole project as a design-and-build project or use the American construction management (CM) approach, where the contractor separates project management from production in order to appear more trustworthy and reliable to the client (Fernström, 1992, p. 102). In 1999, Skanska, a large Swedish group announced its profile as a service company, providing knowledge and competence, and not as a traditional construction company (Appelgren, 1999). Similarly consulting engineers try to be more on the offensive in the execution phase of construction projects and obtain assignments as independent consulting engineers (advisory services, SCC, 1999, p. 12), as problem solvers at site, and to get project management assignments (in Swedish: byggledningsuppdrag). According to SCC (1999, p. 13) the facilities management sector is growing, and this was identified as another business opportunity. Another emerging trend among large international consultant firms (particularly North American) is to leave consulting and to become a full facilities service provider, which paves the way for partnerships and alliances (AI, 1999).

The large Swedish consulting engineer firms compete also in foreign markets. J.G. Richert was early to see that his company had to be international. Between 1901 and 1914 Richert's company did many jobs in Russia, Finland and Norway (Richert, 1929). The company also established a London office. The international operations were not merely seen as profit opportunities but also as opportunities to learn and gain experience from new assignments. Swedish technical consultants have had a strong tradition in international operations since at least the 1970s and 1980s, as they had to seek business opportunities abroad in response to the domestic stagnation in demand, especially for infrastructure. In the early 1980s many of the large Swedish technical consultants had 20 per cent to 40 per cent of their sales in foreign markets (Svensson, 2000, p. 162). This should be compared with SWECO, considered to be a large export consultant, with exports accounting for 13 per cent of sales during 1998 (AI, 1999). However, no large Swedish construction consultant is able to parallel the rapid internationalization of Skanska, the largest construction contractor based in Sweden (Skanska, 1998, p. 19). In an empirical study (including architectural and engineering services and others) Erramilli and Rao (1990) suggest that the international expansion of professional service firms is closely linked to the international activity of their national clients. This is also obvious for Swedish consultants as they follow other firms with a traditional Swedish base such as ABB, AstraZeneca, Ericsson, SKF, Volvo, and Pharmacia abroad (see for example KM, 1998, p. 24).

Developing closer collaborative links between firms not only leads to more jobs. Barlow and Jashapara (1998) show in an empirical study that partnering promotes learning and knowledge transfer between organizations. New knowledge has to be adopted to compete in an international market, and people are encouraged to accept assignments abroad for periods, possibly in alliances, to obtain such knowledge. International alliances and networks are becoming more common, including some Swedish participating consultant firms (AI, 1999). Cooperation with other consultants in international networks is also increasing as a result of standardization of rules and procedures at an international level (KM, 1999, p. 10).

1.4.2 The market for professional workforce

Just as there is a market for the services of professional service firms, there is a market for a professional workforce (Maister, 1982). Recruitment, according to AI (1999), J&W (2000a), KM (2000), SCC (2000) and SWECO (2000) is a major task. There is a need for technical consultants in construction to undergo rejuvenation. Average employee age for the Swedish technical consultant is 43 years and almost one third of the employees will retire in a

period of ten to fifteen years (AI, 1999). The age structure of architectural and construction related firms is very different than that of manufacturing related technical consultancy firms (average employee age: 33 years) (see Table 1.2). On the one hand, it can be seen in the annual reports of the large architect and construction related consultants that they emphasize rejuvenation and young employees. On the other hand, technical consultants in manufacturing emphasize that they are becoming more mature and have many years of experience. As many as 17 per cent of the consultants in architecture and construction are expected to retire in 10 years and another 27 per cent in 10 more years, so compared to manufacturing related technical consultancy firms there will be a large need to hire people.

Table 1.2 Age distribution (%) in architectural and construction related consultant firms compared with age distribution in manufacturing consultant firms (AI, 1999).

Industry\Age	20-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-
Architecture and Construction	4	11	14	15	12	12	15	11	6
Manufacturing	10	29	24	14	9	6	5	3	0

The rate of staff turnover during 1999 was 12 per cent in J&W (J&W, 2000a), 18 per cent in KM (KM, 2000), 18 per cent in SCC (SCC, 2000) and 16 per cent in SWECO (SWECO, 2000). Companies such as J&W and ÅF have officially announced a need for recruitment (AI, 1999) and J&W have also introduced a “new-colleague incentive” to stimulate employees to encourage people they think will fit the organization to apply for jobs there. The need for recruiting professionals with knowledge in areas such as environmental engineering, project management and IT exposes technical consultants to competition from firms not traditionally in the construction sector. Low pay, poor image and low turnover per consultant (MSEK 0.73) are disadvantages when compared to firms such as IT consultants (MSEK 1.05), management consultants (MSEK 1.60) and accountants (MSEK 0.80) (AI, 1999). Another problem with recruiting is the decreasing number of skilled people with degrees. There has not been a successful replacement for the upper secondary school engineering programme (in Swedish: gymnasieingenjör) that was discontinued in the early 1990s. Svensson (2000, p. 20) emphasizes that technical consultancy firms are one of the purest example of knowledge-intensive firms. Staff homogeneity is also high, as many as 70 per cent to 80 per cent of the employees being engineers or natural scientists.

1.4.3 Ownership structure

A look at the top fifty Swedish groups of technical consultants and architects in 1998/99 (AI-företagen, 1999) reveals that from an owner perspective there are three categories of firms: (1) the eight or so largest groups, quoted on the Stockholm stock exchange, with staff numbers ranging between 800 and 2,000

and who mostly have a history going back more than one generation of owners; (2) medium (50 - 200 employees) groups with a history of more than one generation of owners, and (3) recent groups, with an average of about 80 employees, dominated by the original partners (Bengt Andreasson, personal communication with author, 9 May 2000).

Distribution of age is important not only when it comes to creating creative environments for employees. Professional service organizations are traditionally characterized by owners (referred to as partners), who are active consultants in the organization. Founders are usually the original partners, and as other consultants become more and more experienced and have created a business network they are made partners. In mature firms the owners usually have higher average age than the average age of all employees. Most of the Swedish technical consultancy firms are owned by partners. The exceptions are those companies quoted on the Stockholm stock exchange and some former government and municipal technical consultancy departments that have been corporatized and are still owned by central or local government.

Architecture and construction related technical consultancy firms are traditionally valued low on the Swedish stock market. This has opened up for new mergers and acquisitions followed by IT based attempts to process re-engineering of the firms. A historical example that failed was in 1983 when Prospector AB, a group to which SCC belonged at the time, was bought by Enator, and its main owner John Wattin, who came from the computer industry, tried to introduce a customer oriented mix of services called technical management (Lindmarker, 1997, pp. 57-60). A recent Swedish article (Peterssohn, 1999) describes an investor speculating about buying large undervalued technical consultancy firms and implementing IT based processes and methods similar to those used in the IT industry and in many large management consultant firms.

1.4.4 Business cycles and the demand for knowledge

During the autumn of 1999 the demand volume increased for technical consultancy firms serving the construction industry. The market development for consultancy services is closely tied to the general building and construction trade cycle which, in turn, depends on the general economic climate. The large consultancy firms serve customers from many categories: government agencies and administrations, industrial firms, municipal and country councils, construction and real estate firms, power producers, etc. Their client structures are dominated by many small businesses. Thus, the ten largest customers of SWECO account for only 25 per cent of their net sales (SWECO, 2000). However, about half of the net sales are related to the public sector, which means that political decisions have major impacts. Customers

such as contractors and other construction related organizations and their need for consultancy services also depend on political decisions, which highlights the importance of the public sector.

Traditionally, the Swedish construction industry has been thought to have been used by central government to reduce fluctuations in the general level of economic activity. As the construction industry came into a crisis in early 1990s, the government decided to invest more in infrastructure such as motorways, railways and telecommunications. Previously, infrastructure construction had been at a low level since the 1970s, and much of the old knowledge and skills had been forgotten or lost when employees retired or went into other areas. During the 1980s, the focus was on buildings, starting with subsidized refurbishment, and ending with an industrial boom period and a huge growth in the production of new office buildings. Much of this activity collapsed over a period of about one year around 1991 and many technical consultancy firms had to reduce their staff and acquire new knowledge, train and educate their employees and transfer employees to infrastructure construction where they were needed.

> In a consulting company, it is vital that the employees have the skills that are sought after by the clients. (SCC, 2000, p. 16)

Special efforts such as full time courses for unemployed engineers in infrastructure building were also made as a national labour market support measure. The national government and local authorities also started to refurbish school buildings to increase the volume of construction work.

During 1999 the infrastructure trend was broken and the investments in infrastructure decreased except for investments in telecommunications. At the same time housing construction increased and is expected to increase further in urban areas (AI, 1999). This signals a new shift in the demand of specialized knowledge.

1.4.5 Information technology

In a scenario that belongs to a not very distant future, technical consultants such as HVAC engineers provide an output that not only consists of drawings and specifications. Instead, IT will enable integrated product models in which simulation of the construction process as well as operations and maintenance can be done. Consultancy firms will provide models for contractors in order to facilitate planning, procurement and final construction on site. Users and clients will be allowed to explore the building before it is built and in the end have products that support the core business of the users more efficiently and that are much more useful in terms of operation, control and of the maintenance of the building. Various operation alternatives can, for example,

be simulated and tested. The developement of models and simulation requires cooperation between technical consultants and suppliers. This is to some extent impeded today because consultants are expected to prescribe *X product or equivalent* in their specifications. Equivalent products can, however, be difficult to find, owing to the sometimes complex customization of the prescribed product. The emergence of more powerful IT will influence both the construction process and the physical product, and the construction sector will also have to take advantage of the new opportunities that IT creates.

For the technical consultant in the construction industry, IT has until recently had the practical sense of CAD applications, engineering tools such as software for structural analysis, spreadsheets and word processing (Björk, 1999; Howard et al. 1998). Since summer 1997 many of the large technical consultancy firms in Sweden have Internet access and have begun implementing intranets (J&W, 1999; KM, 1999; SCC, 1999; SWECO, 1999; ÅF, 1999). In early 1998, J&W published its general management system (in Swedish: företagssystem, including subsystems such as quality assurance and environmental management) only on the intranet. KM, SCC and SWECO soon followed. In January 1999, the Nordic countries, the United States and Canada were among the most wired countries, with seven to eleven Internet hosts per 100 inhabitants, compared with an OECD average of less than four (OECD, 1999). The IT environment and its infrastructure for Swedish technical consultants is among the most developed in the world.

Information technology (IT) has an important effect on how consulting engineers operate. Betts and Ofori (1992; 1994) suggested that IT offers strategic opportunities to gain competitive advantage, improve productivity and performance, enable new ways of managing and organizing and develop business (see also Raykun, 1996). However, Dawson (2000) recognizes technology as an important source of competitive advantage, but only in a short term perspective, as competitors will implement the same technology. Sincoff (1998) stresses the importance for large international firms of taking the lead in development, and the importance of that the design profession recognizes the role of knowledge-based work and take advantage of emerging technologies in order to bring value to clients. J&W, KM, SCC and SWECO have since 1998 invested heavily in platforms and applications related to their intranets. Through its subsidiary KM Net, KM has developed software for knowledge mapping. However, according to SWECO (2000) the effect on profitability of using advanced IT tools is impossible to identify in the Swedish technical consultancy industry. They assert that the rising costs of building advanced IT systems will necessitate increased networking among smaller firms or continued structural change in the industry before real effects can be seen.

Recent developments in information technology has reduced the amount of less complex work to be performed by white-collar workers. Work that requires individual judgement will remain as well as the tasks of maintaining technological systems. The ability to use the new technology requires new knowledge, which in turn will create a competitive advantage (Stjernberg et al., 1989, pp. 10-11). There seems to be a trend towards a higher level of abstraction and larger elements of problem solving for most professions (Stjernberg et al., 1989, p. 26). This trend can be explained as emerging from new information technology and the consequent integration of functions.

Integration of functions implies that tasks are brought together, both vertically and horizontally in the organization. The content of work is enriched, which in turn demands more knowledge from the employees. New information technology contributes to this enrichment by enabling a project manager to do the project accounting on site with the help of an advanced project server, which contains the business system for the entire organization. Today, engineers make drawings and write specifications on their computers, which has already made draughtsmen and secretaries redundant.

Since construction consultants are knowledge intermediaries in their sector, they may not survive disintermediation which might be a consequence of progress in IT (Bröchner, 1990). However, there is no observable tendency that clients and contractors eliminate consultants in the Swedish construction sector. Instead IT is said to make internal processes and communication more efficient.

> IT makes internal processes more efficient and gives the consultants better scope to give customers the service and quality they demand. ……. This incorporates relevant reporting and follow-up of business activities, administration, storage of business information, both internal and external, and rapid communication between employees. (SCC, 1999, p. 15)

Information systems such as accounting systems, management information systems (MIS), and procurement systems can alternatively be seen as “base technologies” in construction. These will have to be in place for a firm to remain in business, but will not offer competitive advantage (Raykun, 1996). Because of the interfirm network nature of construction design, consultant firms are forced to update software and upgrade hardware to be able to participate in projects. This costly necessity is accentuated by successive releases of CAD software, which seriously test the ability of the employees to learn new features and understand what opportunities they will bring. The development of IT tools thus both simplifies learning and creates new needs for learning.

1.4.6 Product technology change

Technology change is conventionally divided according to the product or the process. Major changes in product technology are not common in the construction industry, which is considered stable and conservative. One reason for the lack of product innovation is the difficulty in predicting the durability of new materials and components. Another explanation is the rigid hierarchical structures for coordinating large numbers of firms in each project (Kadefors, 1995). Prevailing processes and patterns for risk allocation in the construction industry have therefore not been designed to cope with changes in product technology. However, recent advances in information technology have provided firms with the means to adjust their processes to the new demands and opportunities new product technologies offer. In a long term perspective information technology can change products as well. One example is the development of intelligent buildings with embedded IT.

After about 1985, the roles of the technical consultants lost some of its clarity. The lines of demarcation between specialized professions such as technical consultants, IT consultants and services provided by accounting firms also became blurred. Competition in traditional markets for construction oriented technical consultant firms forced the firms into more profitable areas such as environment, manufacturing technology, energy, project management and training during the 1990s (KM, 1999). A shift in tasks is noted from traditional design towards analysis, feasibility studies, conceptual design (early phases), single-point responsibility packages (costs, design, market, etc.) and special assignments using advanced technical equipment. Emerging areas of interest for the development of construction technology are modular buildings, light buildings, energy efficiency, and environmental considerations (AI, 1998). However, R&D in construction technology is usually performed at universities and by larger manufacturers, not by consultants.

Fierce price competition in the consulting engineer industry has led to low profitability, it is generally thought (J&W, 1998; KM, 1999; SCC, 1999; and SWECO, 1999). A low rate of change in construction product technology contributing to a market situation where small entrants to the industry face low barriers to entry appears to create vicious circles. Anecdotal evidence may illustrate the problem when customers lose trust. A friend of mine who works for a computer consultant firm, told me about his manager who phoned a large architectural firm in Göteborg and asked if they could really consider themselves reliable architects and advisors to his firm, for an hourly fee of less than half what a computer consultant would charge. Low prices can give an impression of low competence and bad advices.

1.4.7 Project information flows

Technology change can lead to better use of internal knowledge and large-scale advantages. In a previous study of technical consultants serving the construction industry, Sverlinger (1996) showed that lack of information distribution, lack of communication, and lack of planning in the design phase seemed to be common. Josephson and Hammarlund (1996) found that defects in design operations owing to lack of coordination and insufficient decision support for technical design were caused, in turn, by deficient design project management and inappropriate or incorrect designs. However, utilizing technology and storing experience in an organizational knowledge base is a challenge to all large technical consultant firms today. Trivial detailed design work is no longer profitable for large firms while it attracts smaller firms that operate with almost no overhead costs. Smaller firms join networks to obtain larger assignments. However, networking to obtain large assignments is not a new phenomenon in construction. It was, in fact, the reason why Folke Jacobson and Hans Widmark founded J&W in the late 1930s and later involved Gösta Lönnborg as the third partner (J&W, 1988).

1.4.8 Learning and training

Industry practitioners think that low prices for their services make it difficult to set aside time in projects for training. Typical training areas are business management (in Swedish: affärsmannaskap), leadership, quality assurance and environmental management. However, investment in employee training is low, J&W (1999) reported representatively for the industry 2.5 (3.0) training days per employee in 1998 (1997). There is a tendency to push training to periods with lower workload. KOMPUT (1995, p. 70), which was an investigation sponsored by the Royal Academy of Engineering Sciences and the Swedish Council for Building Research, echoed the profession, saying that there is too little time for training in boom periods and it is too expensive in a depression. Perhaps the technical consultants in construction have been trapped in commercial relations that offer little incentive for investments in training.

1.5 Knowledge management

This chapter has thus far discussed the production of professional services in the Swedish construction industry and given reasons for the importance of knowledge as a basis for competition. What will a technical consultant organization encounter as it enters the world of knowledge management? They encounter management consultants, IT consultants, experience of previous assignments of these two types of consultants, new information

technology, and methods based on the most recent management literature in the field. The next section aims to summarize knowledge management as it is presented in the management literature and by management consultants and others the technical consultant firm will encounter.

1.5.1 What is knowledge management?

It has been claimed by Beckman (1999, pp. 1-2) that Karl Wiig coined the concept of *knowledge management* in his keynote speech at the International Labour Organisation Conference in 1986. However, knowledge management as such is nothing new. It has appeared under different names over the years, but not until recently has the term knowledge management become widely used. Tiwana (2000, p. 9) points out that the concepts driving knowledge management today are some of the same pervasive threads that have run through business for a long time. He mentions earlier trends such as the spread of PERT (Program Evaluation and Review Technique) in the 1950s, centralization and decentralization in the 1960s, the experience curve in the 1970s, corporate culture in the 1980s and finally the learning organization in the 1990s. His point is to dispute the claim that knowledge management is new and appeared almost out of thin air, as some consulting firms would have one believe.

Management thinking during the 1990s has been profoundly influenced by the development of information technology. When knowledge management as a concept gained currency among leading management consultants in the mid-1990s (for a review see Wiig, 1997c), it was probably seen as an attractive synthesis of tendencies present in the TQM movement (Deming, 1986), Organizational Learning (Argyris and Schön, 1978; and Senge, 1990), Lean Production (Womack et al., 1990), and Process Reengineering (Hammer and Champy, 1993; Hammer, 1996). Systems thinking in the late 1960s was another background influence (Wiig, 1997c). Knowledge management also seems to have inherited many features from Information Systems Management (ISM). However, ISM could be perceived as belonging to the world of mainframe computers. Decentralized PC based IT, the Internet and better telecommunications may be three decisive factors for the emergence of knowledge management as a concept.

As is often the case with vague concepts that lie close to professional jargon, is it difficult to find a clear, well-established definition. However, as we shall see, most writers on knowledge management see it as a process of getting the right knowledge at the right time to the right people so it can be of the greatest possible value for the organization. Taking this view which is clearly influenced by logistics, it is no surprise that knowledge management is said to be much the same as information management. This is a particularly common

view among infoenthusiasts who, according to Brown and Duguid (2000, p. 124), define the core problem in terms of information, so that in a second step, they can put solutions in the province of IT. With such systems, retrieval of knowledge will be just as simple as searching for information. Instead as Brown and Duguid observe, knowledge may be easy to search for, but difficult to retrieve if retrieval implies detaching it from one knower and attaching it to another. Knowledge management is thus assumed by them to include more than a traditional IT solution to information problems.

Van der Speek and Spijkervet (1997) take a control perspective of knowledge management. According to them it can be defined as the explicit control and management of knowledge within an organization aimed at achieving the objectives of the firm. Similarly Wiig (1997a) asserts that knowledge management is the systematic, explicit, and deliberate building, renewal, and application of knowledge to maximize the knowledge-related effectiveness and returns from all knowledge assets of an organization. This perspective is also quite control-oriented, at the same time focusing explicitly on treating knowledge as an asset.

Hibbard (1997) sees knowledge management more as the process of capturing a collective expertise of the organization wherever this expertise resides: in databases, on paper, or in the heads of people, and distributing it to wherever it can help produce the biggest payoff. In another process perspective proposed by O'Dell and Grayson (1998), knowledge management is assumed to be all systematic approaches to finding, understanding, and using knowledge to create value. Davenport and Prusak (1998) similarly suggest a knowledge transfer process that consists of generation, codification and transfer of knowledge. Knowledge transfer is a concept that often recurs in literature. To avoid further confusion it is assumed here that when knowledge acquired in one organization (or organizational unit) affects another (either positively or negatively), transfer occurs (Argote, 1999, p. 145). Consequently, knowledge transfer will also include codification in the terms of Davenport and Prusak (1998).

Sarvary (1999) proposes a fourth perspective where knowledge management is seen as a process but, in contrast to the previous process perspectives, he integrates it with the business process. He asserts that knowledge management itself is a business process through which firms create and use their institutional or collective knowledge.

In terms of studying organizations and their business and understanding how they manage their knowledge, it is here assumed that a process perspective is more fruitful than a control perspective. The working definition of knowledge management used in this investigation is that *knowledge management consists of all*

initiatives an organization undertakes to create and transfer knowledge. Examples of such initiatives are discussed in the next section.

1.5.2 Practical examples of knowledge management initiatives

Ponelis and Fairer-Wessel (1998) introduced the idea of people-centred and technology-centred approaches to knowledge management. People-centred approaches are human resource centred and primarily involve assessing, changing and improving individual skills and behaviour. Technology-centred approaches are primarily involved in construction of information management systems, artificial intelligence and implementing groupware solutions. Placing technology first is, as Ponelis and Fairer-Wessel (1998) assert, almost certain to invite failure of the knowledge management initiative. Instead they suggest (similarly to Brown and Duguid, 2000) a balance between the two approaches, because even when people possess knowledge, they also need technology for storing, retrieving and sharing it.

Like Ponelis and Fairer-Wessel (1998), Hansen et al. (1999) have studied knowledge management practices in three service industries. They found two different knowledge management strategies: the codification strategy and the personalization strategy. Codification implies coding information and storing it electronically in an organizational memory, independent of the person who developed it. The personalization strategy focuses on dialogue between individuals. It is based on learning by mapping knowledge of the individuals and it approaches these individuals directly, which also captures tacit knowledge, in contrast to the codification strategy. Comparing these strategies, it can be found that the technology-centred view proposed by Ponelis and Fairer-Wessel is similar to the codification strategy proposed by Hansen et al. People-centred approaches can, similarly, be paired with personalization strategies. Both views suggest that a balanced mix between pairs of strategies is the most appropriate way of working.

Strategies such as these are realized through knowledge management initiatives that more or less support various stages of knowledge management as a process. De Long et al. (1997) have developed a taxonomy for such initiatives. They mention seven types of initiatives: (1) capturing and reusing structured knowledge; (2) capturing and sharing lessons learned from practice; (3) identifying sources and networks of expertise; (4) structuring and mapping knowledge needed to enhance performance; (5) measuring and managing the economic value of knowledge; (6) synthesizing and sharing knowledge from external sources; and (7) embedding knowledge in products and processes. It is also possible to implement parts of all these initiatives using the method of mixing two pairs of strategies described above.

In another study based on 431 U.S. and European organizations, Ruggles (1998) mapped knowledge management initiatives under way, from an information systems perspective. The four most common knowledge management initiatives were found to be: (1) creating an intranet, (2) data warehousing or creating knowledge repositories, (3) implementing decision support tools, and (4) implementing groupware to support collaboration. It is obvious that most organizations concentrate on technology support. This is interesting since the three things managers most often said they ought to be doing, according to Ruggles (1998), were more or less people-oriented: (1) mapping sources of internal expertise (who has what knowledge), (2) creating networks of knowledge workers, and (3) establishing new knowledge roles (Chief Knowledge Officer, etc.). This indicates a divergence between what people say they do and what is actually done. Managers admitted that changing the behaviour of people and culture represented the greatest obstacles when managing knowledge. It therefore seems that managers, in working with technical solutions, choose the path of least resistance when approaching knowledge management (Ruggles, 1998). This may explain why most knowledge management initiatives have until recently been technology centred. But, as mentioned above, technology is not enough to manage knowledge. Examples of knowledge management initiatives described in the mainstream literature are presented in Table 1.4 and 1.5, using the strategy terminology proposed by Hansen et al. (1999).

Table 1.4 Examples from literature of knowledge management initiatives following a codification strategy.

Organization	Knowledge management initiative
Arthur Andersen	Arthur Andersen uses a hybrid solution for knowledge management consisting of competency centres, the Global Best Practice CD-ROM, the KnowledgeSpace, and AAOnLine. The KnowledgeSpace is Arthur Andersen's major knowledge management intranet repository. AAOnLine is a database based on Lotus-Notes, that has been created especially for knowledge distribution and sharing. Other important groupware tools in Arthur Andersen's KnowledgeSpace include the Client Service Connection database and the Contact Management (Elliot, 1997). The support features of the KnowledgeSpace include: advice – coaching at important moments in work flow; tools – integrated, customisable job aids for project management, computation, and document creation; reference – job-relevant information that is internal or external to the organization; and training – tutoring, examples, and practice delivered on demand (APQC, EFQM, KMN, 1997).
Chevron	Has created a best practice database. It captures experience of drilling conditions and innovative solutions to problems on site in a database for sharing globally with other sites. Chevron has also implemented a best practice resource map (APQC, EFQM, KMN, 1997).
General Electric	Answer centre in USA: GE has collected all customer complaints in a database that supports telephone operators in answering customer calls since 1982. GE has programmed 1.5 million potential problems and their solutions into its system (Nonaka and Takeuchi, 1995, p. 69).
KPMG	KPMG has created a network called K-World which makes expert knowledge base systems and on-line information sources available. It facilitates knowledge sharing, messaging and team and client collaboration. KPMG also works with staff training and development programmes, reward and recognition policies and with mentoring to improve the knowledge management environment (Parlby, 1998; 1999).
Netscape	Netscape has developed very close links via the Internet to opinion leaders among customers, who are encouraged to report problems and enable it to create new generations of software at a very fast pace (Sveiby, 1997).
SAAB Ericsson Space	QUEBASE (Quality Under Evaluation dataBASE) was developed at Saab Ericsson Space as a system for handling non-conformance reports (Berlin, 1994). It makes non-conformances available for design teams, manufacturing, testing as well as the client.

Table 1.5 Examples from literature of knowledge management initiatives following a personalization strategy.

Organization	Knowledge management initiative
American Management Systems (AMS)	Communities of practice involving 800 expert practitioners coordinated by 17 leaders at knowledge centres supported by 80 staff members and a large infrastructure. The infrastructure consists of e-mail, intranet, voice mail, video conferencing, a full reference library (library, notes databases and a data warehouse) and a phone service called Know Hotline. Newsletters from knowledge centres and best practice award for creation and reuse of knowledge assets (Hanley, 1998).
British Petroleum (BP)	Teamwork and networking, often in virtual teams. Transfer of skills and know-how through technology support and continuous development of norms, culture, and operating procedures. Emphasizes more transfer of tacit knowledge than accumulation and transmission of raw data and has installed a communications network comprising video-conferencing, multi-media and e-mail (Lloyd, 1996).
Hewlett-Packard	Known for its overall culture of collaboration, which encourages knowledge sharing and risk taking on all levels. HP even supports people who try things that usually do not work. Examples include the open-door policy, managing by walking around, and offices on preferably one floor, furnished in open landscapes which promote transfer of tacit knowledge (Martiny, 1998).
McKinsey & Co.	McKinsey has a knowledge management system that is especially suited for inter-project learning. Practices and the Rapid Response Network (RRN) are of special interest. Practices are internal expert groups or think tanks where people meet and discuss specific topics. RRN is a computer system that contains the document database and personal competence profiles of the consultants. Two permanent employees also support it. The RRN keeps and manages all project experiences from all consulting projects. Consultants can be provided with, for example, experience reports and documents retrieved from a searchable document database and can be assigned a contact person for their specific problems (Peters, 1993).
Skandia	Measures processes using non-financial indicators. Publishes the world's first Annual Report supplement on Intellectual Capital. Development of cross functional teams to foster organizational learning (Jobring and Targama, 1995; APQC, EFQM, KMN, 1997)

Although many attempts have been made to manage knowledge, not all of them have been successful (Ruggles, 1998; Storey and Barnett, 2000). Literature usually calls attention to projects considered successful (Davenport et al., 1998). Other initiatives we never hear about probably compose the vast majority, successful or not. We need to learn from them, too, in order to improve, at least to understand why initiatives fail.

1.6 Towards a process perspective on knowledge

The recent focus on knowledge management discussed above has not bypassed technical consultants unnoticed. If we examine the work of the large technical consultancy firms from 1997 to 1999 we can see that a considerable amount of work has been done, and many initiatives are quite new. The latest annual reports spend pages discussing culture, human capital, structural capital, competence, knowledge management and customer satisfaction. Technical support systems and IT are said to integrate the use of general management systems and performance of operational tasks. It can be argued that these annual reports are influenced by a wish to impress investors, but it must also be admitted that similar information can be found in the press and heard from employees and research colleagues that cooperate with consultancy firms.

New management principles have been developed to emphasize processes, coordination and efficient use of resources, as we just saw in section 1.5.1. The quality movement has been particularly important in terms of beginning to structure knowledge in the firms, but this is just a start when it comes to integrating all knowledge in a firm and its business processes. The leading companies in the manufacturing industry have experienced the full range of management trends, and they have also transformed approaches to the way work is managed. Technical consultancy, by contrast, has not really changed in a process sense since it came into being in the late nineteenth century, as will be discussed further in Chapter 2. However, management trends in manufacturing have contributed, during the late 1980s and 1990s, to an increased interest in quality issues in construction. In practice, organizations have created a number of quality assurance systems, which have usually been implemented top down, have not been accepted readily by many employees, and have often failed in use. Nevertheless, as such quality systems have often led to certifying arrangements, they have become a kind of licence for access to the construction market (Lantz, 1996).

Quality assurance and being certified according to ISO 9000 standards can be said to be recent attempts to coordinate and standardize work. Standardization of work, as it was described by Thompson (1967), is one way of accumulating best practices in an organization. Technical consultancy firms try to manage and integrate knowledge that resides in individuals (human capital) into the general management systems or parts of it in many ways, such as quality assurance systems or databases available on the intranet, where it becomes structural capital (see J&W, 2000a; KM, 2000; SCC, 2000; and SWECO, 2000). In order to keep knowledge updated, knowledge management also includes continuous efforts in learning as well as unlearning, as is later to be discussed in Chapter 2. Lantz (1996) refers to the then current debate about the large amount of work following certification, as processes are refined, in order to implement a system for continuous improvement (CI). In other industries the concept of CI has been realized in various tools and techniques and it has been deployed through quality control circles, work teams and other formal arrangements (Bessant, 1997) that support communication and learning.

Previous studies of the Swedish construction sector indicate that the local knowledge process is determined by the requirements of operations (Ekstedt et al., 1992; Ericson and Johansson, 1994, p. 20). Most knowledge is acquired within projects, and this is said to be a problem because it is neither systematized nor founded on a scientific base. Knowledge is developed through practice and it is personally and subjectively based on a specific project or assignment. It has therefore been difficult, so far, to internalize new knowledge into the organizational memory. In absence of parametric design

methods, in a model-based system, the reuse of design solutions is often unattractive and relatively inefficient.

If we raise our view above the level of the individual firm, the construction process that transcends boundaries between architects, specialized consultants, contractors and clients, is dependent on the ability of the participating organizations to transfer knowledge. Quality and cost failures are often ascribed to faulty management of information flows between firms involved in a single construction project. Attempts to create a common platform for the entire design and construction process (Cooper et al., 1998), sometimes also including the knowledge needed for facilities management, have been made at least since the 1980s, but until now with little practical impact. In spite of the quality movement and investments in information systems in construction, there seems to remain a considerable potential for sharpening quality focus throughout the construction supply chain.

1.7 Aim and objectives of the investigation

Technical consultants work mainly in the same way as they did in the late nineteenth century when consultancy was a new phenomenon. Methods have changed little and it was not until recently that radical changes in division of labour have taken place, as computers have become common. Market trends and the pressure from some owners of consultancy firms have started to place new demands on technical consultants. However, when computers were introduced, technical consultants gained access to efficient tools that support their processes and add more structure to their knowledge. The individual consultants were no longer allowed to produce knowledge only for local use if the firm should stay competitive, especially in new markets where they compete with organizations, such as management consultants firms, that do not mainly serve the construction industry. The development of better tools for knowledge management facilitate changes and implementation of more structured approaches to managing knowledge. However, such structured approaches, containing both people-centred and technology-centred initiatives, are usually offered by other consultancy firms. Many of these firms also include business units that compete with technical consultants in areas, such as environmental management, quality management and project management, that will learn how to manage knowledge from the knowledge management business unit. In the future it will therefore be important for technical consultancy firms to achieve world class abilities to manage knowledge in order to stay competitive.

The aim of this investigation is *to create an understanding of how technical consultancy firms serving the construction industry manage knowledge*. The broader purpose is to

develop a framework for knowledge management in technical consultancy firms. This investigation is limited to the four largest Swedish firms. The level of analysis in this investigation is, however, not the firm but the department within the firm and, in parts of the analyses, the individual consultant. The period studied is from the autumn of 1997 to the spring of 2000.

There are two principal objectives in this investigation, following from the discussion above. The first concerns the knowledge transfer process and how it is supported by the way technical consultancy firms are organized, in other words: *how do technical consultancy firms serving the construction industry transfer knowledge?*

The second objective is related to process support tools. In section 1.4.5, it was concluded that technology changes lead to development of new process support tools. Such tools are also assumed to enable transfer of knowledge. *What is the role of process support tools in enabling transfer of knowledge within technical consultancy firms?*

1.8 Structure of the dissertation

This dissertation is divided into nine chapters. Chapter 1 has presented a literature review of the technical consultancy industry and its focus on knowledge. It was followed by a review of recent trends in knowledge management. The aim of the investigation and main objectives were stated.

Chapter 2 begins with modelling the technical consultancy organization as a professional service organization. Knowledge and personnel are found to be primary resources of such firms. An understanding of knowledge and how it is created and transferred is presented for the tacit and explicit dimension as well as for the organizational dimension. The tacit and explicit dimension of knowledge is discussed according to the process of knowledge conversion proposed by Nonaka (1994) and it is complemented by the traditional perspective of organizational memory and the knowledge transfer process. Enabling conditions and facilitating activities for learning and knowledge transfer are discussed. Knowledge transfer and organizational learning are combined into a model of knowledge management in technical consultancy firms. Chapter 3 includes a discussion of the objectives leading to research questions.

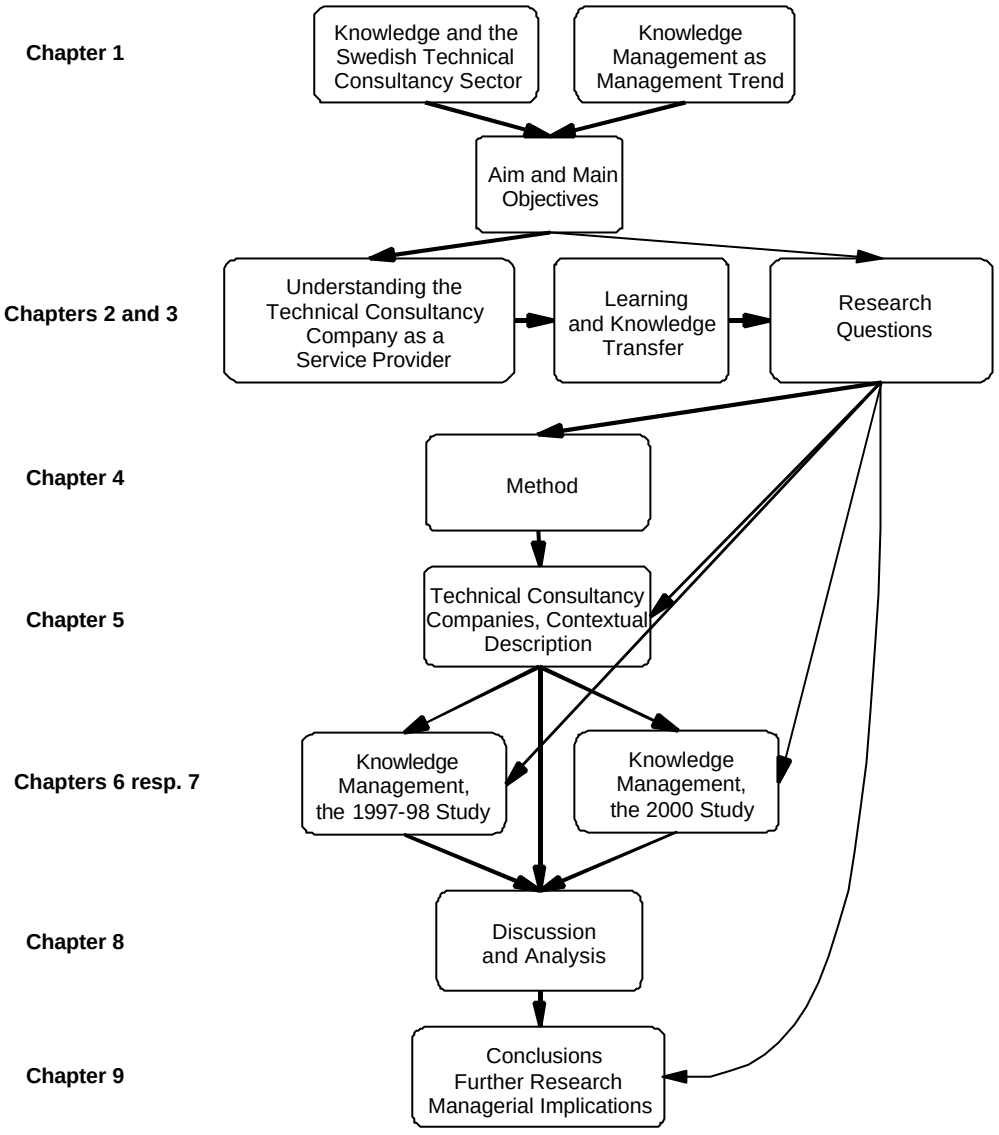

Figure 1.2 Structure of the dissertation.

Chapter 4 examines issues about the methods used. The research methods chosen combine quantitative and qualitative approaches. One department was chosen from each of the largest four Swedish technical consultancy companies serving the construction industry. The four companies have been surveyed in two separate studies, 1997-98 and 2000. The first study consists of a quantitative competence development and learning questionnaire survey, qualitative interviews, observations and a selection of documents from the four firms. This study gives an understanding of the industry and the context in which tasks are performed. The second study was performed to deal with the major technological developments and changes over a period of two years. It includes interviews with employees in the same four firms. A second questionnaire survey including selected questions from the first questionnaire to which have been added new and more specific questions on knowledge

management was also carried out. The chapter ends with a description of the guidelines for the analysis.

In chapters 5 to 7 the results of the two studies are presented. Chapter 5 begins with an overview of the business processes including the project management process and the characteristics of technical consultancy assignments. The intention is to provide a context in which the assignments are carried out and knowledge is managed. The empirical data come from observation, written internal documents, intranets, project documentation and interviews from both studies. This chapter also gives an overview of enabling conditions and facilitating activities by presenting recent knowledge management initiatives in the four firms.

Chapter 6 presents results from the 1997-98 study. It includes descriptive statistics from the knowledge management questionnaire to which have been added data from 31 interviews. Chapter 7 is structured similarly to Chapter 6 but presents the 2000 study.

Chapter 8 includes comparative analyses of the first and second study in relation to the context for knowledge management presented in Chapter 5. The discussion of empirical data is structured and discussed according to the theoretical model of technical consultancy organizations developed in Chapter 2. Organizational and technological change between the 1997-98 and 2000 studies are discussed in order to find areas for improving the knowledge transfer process. Chapter 9 begins with a review of the research questions and their answers followed by a discussion of generalizing the findings. Suggestions for further research and managerial implications conclude the dissertation.

2 Theoretical frame of reference

This chapter introduces the technical consultancy organization as a professional service organization. Knowledge and personnel are discussed as primary resources and also as sources of differentiation in professional service production. An understanding of knowledge and how it is created and transferred is presented emphasizing both the tacit-explicit dimension and the organizational dimension. The tacit and explicit dimension of knowledge is discussed in the light of the process of knowledge conversion as proposed by Nonaka (1994) and it is supplemented by the traditional perspective of organizational memory and the knowledge transfer process. Furthermore a number of enabling conditions and facilitating activities for learning and knowledge transfer are discussed. Aspects of theories of knowledge management and of organizational learning are combined into a model of knowledge transfer in the technical consultancy organization.

2.1 The professional service organization

The professional service organization can be identified according to its distinguishing characteristics. These organizations gain competitive advantage partly by differentiating. Their functions can be understood by applying a simple input/output model.

2.1.1 Characteristics of professional service organizations

There are many types of service organizations. Some service organizations are particularly dependent on well-educated and skilled personnel. They belong to a group called professional service organizations defined, according to Nachum (1998, p. 37), by two features:

> First knowledge is their core resource, and it is both the input and output in their production processes. Second, their clients are other firms or institutions, and their output is used as input into the production processes of other businesses.

Maister (1982) stated that professional services usually involve a high degree of interaction with the client, together with a high degree of customization. Both of these characteristics demand that the organizations attract (and retain) highly skilled individuals. There is also often a concentration on temporary assignments or projects. This puts special requirements on processes, management and organizing, different from those in traditional mass producing industries. Much of this is summarized in Alvesson's (1992, pp. 16-17) useful review of Gummesson (1990), Hedberg (1990), Starbuck (1990)

and Sveiby and Risling (1986), which characterizes the professional service organization with the following six criteria: (1) essential features of problem solving and non-standardized production; (2) creativity of the individuals as well as within the organizational environment; (3) strong individualism and independence of the individual; (4) most employees are highly educated professionals; (5) traditional assets are not central (the critical elements are in the head of the employees, in networks, customer relations, manuals and service delivery systems), and (6) strong dependence on employee loyalty and therefore vulnerability to exits.

This characterization focuses on the employees and their characteristics rather than the organization, but it should not be forgotten that employees work in creative teams and networks together with the customer, using the organizational service delivery system. Employees in a professional service organization can be said to perform knowledge work (Davenport et al. 1996; Starbuck, 1996; Nachum, 1998). Davenport et al. (1996) further agree with Alvesson's (1992) review in that knowledge work is characterized by variety and exceptions rather than routine, and it is performed by professional or technical workers with a high level of skill and expertise. However, they also assert that the primary activity in knowledge work is the acquisition, creation, packaging, and application of knowledge. Cooper and Argyris (1998, p. 351) basically agree with this characterization, but they emphasize the importance of the individual and the requirement of employees who can use their own knowledge base, acquire new information, combine and process information to produce and communicate new information and knowledge outputs and learn continuously from their experiences.

2.1.2 Differentiation and competitive advantage

What were formerly quite distinct professions are now gradually merging into a broader field of professional services (Normann, 1991, p. 32). Similarly as for the technical consultants as presented in Section 1.4.6, cases from accounting, advertising, investment banking and legal service industries show that these industries have shown tendencies to converge into one professional service industry. Multidisciplinary practices bring together professionals from many specializations within a single organization. KPMG has, for example, several key areas in 2000: assurance, tax and legal consulting and financial advisory services. This development has resulted in more entrants to each of the traditional markets. At the same time what has been seen as traditional services has been cut into smaller components. Normann (1991, p. 33) mentioned unbundling due to deregulation. Smaller competing organizations have chosen to offer individual aspects of services that have opened up to

specialized competition. Recently, large organizations which have provided both auditing services and management consulting are seen as unbundling.

Convergence as well as unbundling into smaller service components can, together with the increasing digitalization of information, the greater availability of information, and more rapid communication, lead to faster diffusion of innovations and lower barriers to entry in a market. Differentiation of the services offered will then be increasingly difficult, and the industry may become price and cost driven with high client mobility. Technology can be a source of differentiation, but as long as the competitors can implement the same technologies, this kind of differentiation will provide only a short-term advantage. In this perspective, the often-cited statement of Arie de Geus (1988) reflects the difficulties in creating competitive advantage:

> the ability to learn faster than your competitors may be the only sustainable competitive advantage.

By taking a learning and knowledge perspective on how to differentiate services, Dawson (2000) proposes three sources of sustainable differentiation: (1) greater specialist knowledge and expertise embedded into products and services, (2) closer and deeper client relationships including better understanding of what generates value to the customer and, (3) greater knowledge transfer to the client, resulting in improved performance within the client organization[1]. No matter what perspective is chosen, creation and transfer of knowledge is critical to the professional service organization. Even when a differentiated strategy is not chosen, internal creation and transfer of knowledge are important for internal effectiveness and ability to be price competitive.

2.1.3 A general model of professional service organizations

Based on the professional service organization as a system for creating and transferring knowledge, such an organization can be discussed according to a traditional input-output model consisting of four elements: (1) resources, (2) information inputs, (3) the service process and (4) output or value to the client.

Resources

Thought of as a resource, knowledge is usually referred to as part of intellectual capital (Roos et al., 1998, p. 24), which can be seen as embedded in both human capital and the organization's structural capital (Sveiby, 1997, pp. 10-11; Roos et al., 1998, p. 31). Human capital, according to Sveiby (1997, p.

[1] Dawson seems to have been inspired by ingredients of a service package described by Normann (1991, pp. 54-55).

10), is the same as employee competence, which involves the capacity to act professionally in a wide variety of situations. Sveiby (1997, p. 8) further distinguishes between internal structural capital and external structural capital. Internal structural capital includes patents, concepts, models, computer and administrative systems as well as organizational culture (Sveiby, 1997, p. 10). External structural capital includes relationships with customers and suppliers, brand names, trademarks, and the firm's reputation or image (Sveiby, 1997, p. 11). In the field of professional services the intellectual capital can be considered a primary resource.

Human capital, or employee competence, is essential to professional service organizations. The ability of employees to manipulate existing knowledge in order to solve specific client problems is what creates the output of these organizations. Therefore, the success of professional service organizations ultimately depends on the competence of their professionals, relative to that of their counterparts in rival firms (Sveiby and Lloyd, 1987).

Professional organizations usually structure their employees in three levels: seniors, managers, and juniors (Maister, 1982; 1993). These ranks may be signs of status as well as of function, as work in the lower ranks of a professional service organization can be viewed as an apprenticeship, where the senior craftsmen repay the hard work and assistance of the juniors by teaching them their craft (Maister, 1982). Ranks are then related to personal knowledge and business networks. Maister (1982) emphasized that the mix of experts, generalists, seniors, managers, and juniors influences the kinds of assignments the organization can accept. The expected output from projects influences the project team structure. Projects are therefore chosen with present resources in mind. If, for example, there is an engineering firm where most employees are seniors and experts, it may be unprofitable to accept easy work assignments such as detailed design with a great deal of repetition. Seniors and experts usually cost more than juniors, and the client may not be willing to pay for expertise. Contrarily, organizations with a large share of juniors cannot accept a high proportion of advanced tasks. Prevailing types of projects in the organizational project portfolio, in turn, influence both the organizational structure and its economy (Maister, 1982).

Internal structural capital supports the business process as it is carried out. Some firms, such as Andersen Consulting and Cap Gemini, have developed operational support systems in order to assure quality, homogeneous performance, and use of best internal practice. Back office staff and previous projects stored in records are also part of the support system.

One trend in the practice of knowledge management has been to shift knowledge from human capital to structural capital. This is achieved by

developing standardized processes, best practices, methods, internal manuals, etc. Where knowledge, in this sense, is formalized and embedded in internal structural capital, it also becomes easier to store and to distribute to the organization. The organization also becomes less exposed to the risk of losing knowledge when employees leave.

As a part of the *external structural capital*, clients (customers) and their networks as well as the networks of the professionals are important resources for professional service organizations. Most new assignments are generated from existing customers or through the networks of former customers and their business partners. The professionals' networks can include customers, public authorities as regulators and stakeholders upstream and downstream in the business value chain. The choice of client also influences the professional development of the organization. A client serviced for a long project will typically drive the evolution of a specific set of skills, which in turn influences the content of the organizational memory (Scott, 1998, p. 81). International involvement of the local clients is important for the growth of the service organization because of its use as a vehicle for expansion abroad.

Most professional service organizations have few fixed assets. An office equipped with furniture, computers, CAD stations, IT network, copiers, and fax machines are often enough to start or maintain a service organization such as a technical consultancy firm. However, the office layout and its opportunities it brings to meet, discuss, cooperate and learn are of importance for knowledge creation and transfer (von Krogh et al., 2000). It can thus be concluded that not only the social environment but also the physical working environment affect the transfer of knowledge in a professional service organization.

To sum up, knowledge is the most important resource in a professional service organization (Brown and Duguid, 1991; Davenport et al., 1996). However, knowledge is only partly similar to capital in a physical sense. Knowledge generally increases the potential output of the organization but the quantity and quality of its impact cannot be known in advance. Unlike conventional capital goods, knowledge has no fixed capacity. Depending on entrepreneurship, competition, and other economic circumstances, a given idea can trigger enormous change, modest change or no change at all (OECD, 1996).

Information inputs

While knowledge has now been treated as a type of capital resource in the model, information shall be considered as the primary input of a professional service organization. To create value for the client, information is acquired from external and internal sources. Using the resources, including knowledge

held by employees, it is processed to an output. Information about client needs is therefore an important type of input. Information about the operating environment such as regulations and other restrictions is also important. Some of this information is available through observations and measurements on site or in the client organization or from analysing previous assignments. Similar assignments and other assignments for the same client will be particularly valuable.

Processes

Owing to the customized and often temporary nature of professional services, most professional assignments are organized on a project basis. There are basically three major processes in the delivery of professional services: client relations, project management, and performance of the detailed professional tasks (Maister, 1982). Managing *client relations* as a process does not end with the acquisition of new or extra assignments. Clients are seen as co-producers in the service process, sometimes being heavily involved in production. Good client relations make communication easier and the service provider finds it easier to understand and fulfil client needs. The importance of client relations in the professional service organization is emphasized by having senior consultants managing them. Studies show that internal service quality can be linked to external service quality (Schlesinger and Heskett, 1991). Employee satisfaction and motivation are often key qualities in service organizations (Rosenbluth and McFerrin, 1992). What employees experience within their organization is transmitted to the customer (Schneider and Bowen, 1993). As customers are co-producers, they perceive at least parts of the work environment of the service provider directly (Normann, 1991). The internal work environment may therefore directly affect customer perceptions of the service quality. Therefore, there is a close link between the first and the second major processes of service delivery.

Project management including coordination with other consultants and public authorities is the second major process. Four constraints that affect the work process are: (1) the delivery day of the final output of the project; (2) milestones in the project where specific tasks have to be completed in order to coordinate with other consultants; (3) product characteristics that affect interorganizational as well as intraorganizational coordination and the order in which tasks have to be started and completed and (4) type of information and knowledge input needed for the project. External acquisition or collecting information on site usually take time and require planning.

Maister (1982) categorized professional service projects into three types: (1) Brains, (2) Grey hair, and (3) Procedure. Brains are extremely complex projects, which require the highest degree of expertise from the organization.

Brains usually contain new solutions to new problems. Grey hair projects may require highly customized output, but less innovation and creativity. The problems will be known from previous projects but to find a solution an expert must be involved to provide knowledge, experience and judgement. Procedure projects, Maister pointed out, usually involve well recognized problems where customization can be accomplished through elements of routine and procedures. Returning to the initial analysis of sources of differentiation, brains are most likely to differentiate a professional service organization from its competitors.

Just as various categories of projects require more or less knowledge and experience from employees, the professional levels (seniors, managers and juniors) of employees allow them to work more or less with certain tasks. Senior consultants work more with client relations, sales meetings, making agreements and mentoring than their less experienced colleagues. As a project starts, it is usually transferred from the senior consultant to a manager (project manager at the middle level) who coordinates the operative project management, more precisely the third major process, namely the process of *performing the detailed professional tasks*. The detailed professional tasks, the operative work, are largely carried out by juniors. Maister (1982) describes juniors as usually younger people (recently graduated) who want to earn the rank of manager and who are not afraid of hard work. They are supposed to be supported by the managers and the professional business system of the organization. Processes, routines and professional coaching from experienced managers and seniors assure that the quality of their output meets client expectations.

Output

Output from professional service organizations include written reports, oral presentations, drawings, software, specifications and inspection protocols. All of these are related to problem solving and they constitute collections of processed knowledge. They are also packaged for transfer to a customer, who generally transfers them further to other organizations.

From a knowledge perspective, output is information that has an added value when it is transferred to a context where it can be used or applied as knowledge. The professional service organization also develops knowledge and expertise for internal use and future external transfer. The existing knowledge of the senior staff is a base the organization will develop continually and build on. This includes creating and transferring knowledge internally. Knowledge can also be externalized and structured instead of tacitly held by employees during a project.

Knowledge seen as a specific type of capital resource is combined with the information input to the service process, it is transformed in the business process and packaged and transferred to the customer as output (Armistead, 1999) and thus it is the result of an assignment. Access to knowledge should therefore be crucial for managing professional service organizations. Access to knowledge also determines what strategies can be realized, what kind of assignments can be accepted, and what kind of customers that can be served.

2.2 A special case of the professional service organization: the construction technical consultancy firm

2.2.1 Characteristics of the business of construction technical consultancy

Construction, or to put it more broadly, changes in our built environment, involves services delivered by several types of professional service organizations. Traditionally, the two major types have been architects and technical consultants. Although these two types correspond to distinct professions in most countries, it is common to find large organizations that offer both architectural and technical consultancy services. However, such organizations tend to be organized basically along the professional fields. The tasks undertaken by technical consultants range over many specializations and are delivered in many ways: reports, design (concept, design development), documentation including specifications and contracts, project management and contract administration, inspection, planning, provision of advice and finally audits (Singleton, 1998). In addition, the independence and strong knowledge and skills of the technical consultants have allowed them to fulfil other, less traditional roles such as project identifier and initiator, promoter or entrepreneur, facilitator, project partner, independent engineer (for privately funded infrastructure), and to provide operations, maintenance, and outsourced engineering work (Singleton, 1998).

Traditionally, professional services are typical produced through face-to-face work, because the execution of consulting services requires some form of interaction. In construction projects most of the professional work is done by “back office staff” without participation or direct interaction with the client. Although most work is carried out by back office staff, it certainly requires information about customer needs. In the case of projects such as designing a private dwelling, the client is often identical with the ultimate customer and future user of the building. Access to ultimate customers varies with the type of construction project; it is unusual that the consultant is able to conduct a dialogue with future road users, to take an example from a type of project where users are remote from the design situation. However, most

construction projects include a high degree of client and user involvement in design and production. This involvement has a process aspect. Cherns and Bryant (1984) have presented a process view with a high degree of client involvement in initial phases of construction projects, and thereafter a retreat of the client organization into a more reactive mode, but their view may no longer be generally valid. Today, clients and users appear to be strongly involved in defining the construction process output in the early stages of construction projects, but there are also often numerous changes during the design and construction process as the project evolves and the output becomes more and more tangible for the users. Interaction with the client also varies depending on speciality and type of construction. In the case of an office building, the architect and the interior designer will interact more with the client and the users, whereas the other consultants will obtain most of the client and user information they need from the other two. Although this process can be seen as a learning process for both architects and technical consultants as well as for other parties involved, its primary output is documents which in most cases are trivial and easy for competing consultants to prepare, had they been selected by the client.

Client interaction usually takes place during meetings and briefings at the client organization. Usually project managers from various consulting disciplines or specializations meet the client or the client representative project manager, who usually hosts the meeting. Such meetings can also be supplemented by other communication media between project managers from various specializations and the client. The project managers will then be responsible for explaining to their project team what has been said and decided. In larger assignments the project team is usually internally specialized, and there may be several partial project managers and consultants who have to communicate to, and coordinate directly with, various user representatives as well as with the other participants in the project. However, distribution and meaning making of information and knowledge included in what Brown and Duguid (1998) call boundary objects (such as plans, blueprints and documentation of interest to each specialization or participant but used differently by each of them), usually involves all team members, not just project managers.

Another characteristic of construction projects is that consultancy services are quite specialized, and although one organization may have many specializations it is not likely that this organization will have the opportunity to sell all their services to one client in the same project. It is not even certain that one specialist knows how other specialists within the same organization can contribute and therefore the organization may miss the opportunity to offer that knowledge to the customer. Specialized consultants from several firms therefore have to coordinate during the successive stages of a project.

Large projects may, in fact, involve hundreds of firms including various specialized consultants[2]. Some consultancy services are also performed by building material suppliers or by consultants contracted by them[3]. Communication and coordination is further complicated by the existence of numerous regulatory authorities, local, regional and national, that are involved in physical planning, protecting the environment, occupational safety and other legal restrictions on construction projects.

The technical consultants also emphasize customer influences on the required competence levels in the construction industry. Clients such as property developers and real estate companies exert a strong influence on the building process from procurement of design to future maintenance and refurbishment. Their needs and requirements, ability to specify services, and to organize and coordinate the process including control and monitoring are thought to be essential for competence development in the construction industry (Johansson and Svedinger, 1997, p. 4).

Technical consultants see themselves as having an important intermediating role in the transfer of knowledge in the construction industry. Traditionally they say they have had the role of bridging the gap between research and practice and transferring knowledge and research results to the industry (Teknikkonsultgruppen, Byggforskningsrådet, 1993, p. 10 and pp. 22-23). Such a role should put great demands upon knowledge management within the organization as well as with external organizations.

Transferring information and knowledge within the organization as well as to other consultants and to the clients are major tasks for technical consultants. Their ability to manage knowledge is important for interpreting the client needs into a design, using the latest experience and delivering the project on time. The ability to manage knowledge and transfer not only to the client but also internally can be a source of differentiation that helps the organization to compete.

2.2.2 Strategies for technical consultants

Very little has been written on strategies for professional service organizations related to the construction sector. However, Winch and Schneider have made

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[2] The most common areas of specialization in Swedish technical consultancy serving the construction industry are structural engineering (buildings or bridges or hydraulic construction), electricity and telecommunications, environmental engineering, fire protection engineering, geology, geotechnics, ground water and water engineering, building services engineering, hydropower, interior design, landscape architecture, management services (such as CAD and document hosting and coordination, design management, project management, project accounting, and site inspection), measurement and cartography, roads and railways, rock engineering, traffic planning, and urban planning. (See also section 1.4.1 for a market overview).

[3] Elevators, industrial kitchens, industrial planning and waste management are examples of such specialities.

contributions to our understanding of strategy selection in this field. Starting from Porter's (1980) well known model of generic strategies, Winch and Schneider (1993a) developed a model with two strategic dimensions for architectural practices: (1) project complexity and (2) preference for quality. Project complexity measures how demanding the project is in terms of the sophistication of specification, technological complexity, size, the rapidity of work required, and special client requirements. Quality preference is related to the extent to which the construction is of a symbolic character and is acclaimed by other professionals as creative and innovative. It can, however, be claimed that technical consultants do not need to be creative and innovative in the same sense as architects. Building on the conclusions of Blake (1992), Winch and Schneider proposed an amendment of the second dimension so as to better reflect organizations trading in technology, such as engineering consultants. Design specificity is then proposed as the second dimension, in which the client can choose a design where the consultants can make use of repeatable design elements and specifications. The client can also choose a solution highly specific to the particular project, requiring an innovative solution or extensive adaptation of existing solutions. The authors claim that this dimension is independent of the technological complexity included in the first dimension. The two dimensions yield four strategies, which articulate particular distinctive competencies and demands on knowledge management (see Figure 2.1).

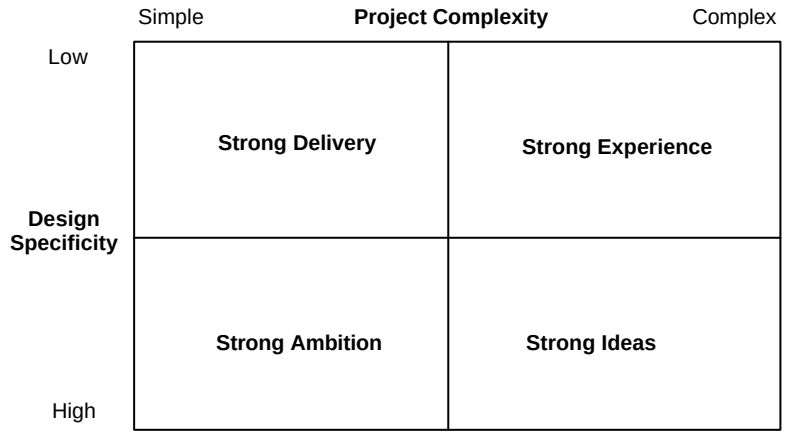

Figure 2.1 Four strategies for technical consultancy firms (based on Winch and Schneider, 1993a).

With the first strategy, strong delivery firms deliver designs for relatively simple building types for lower than average fees, but with relatively high profitability thanks to effective organization. These firms use standardized processes, modularization, CAD and other technical process support tools. This kind of strategy implies that the firm has to spend a great deal of effort on making knowledge explicit and embedding it in the internal structural

capital. Strong delivery firms are often functionally organized and have good project managements, in order to ensure delivery performance on time to the specified budget. Many of those projects can be classified as procedure projects, using the project typology presented by Maister (1982).

In adopting the second strategy, strong experience firms offer technically complex or unusual buildings. The consultants are often specialized in the particular building type and have made similar designs before, from which they can reuse solutions and contribute to the all over value of the client. Here there are many similarities with Maister's (1982) second type of projects, grey hair projects. Networking to learn where to find knowledge and expertise is essential. Fees are average and above average, and it is common that larger firms are multidisciplinarily organized on a matrix basis around strong project teams.

Strong ideas firms, representing the third strategy, live on their reputation and on their ability to create original and functional ideas just as in the case of architectural practices. Fees will usually be premium, as these firms are well known and give a great deal of added value for the client. Technical complexity as well as design specificity are high because the requirements of the client are unusual and standard solutions are not available. External networks and communication seem to be important ingredients in such an organization because it needs to be susceptible to external impressions if it is to sustain its innovativeness. Such firms are often smaller and organized around one or more strong experts, who are often the founders. This corresponds well with the first type of project, brains, in the classification by Maister (1982) who argues that this project type requires a great deal of work from experienced senior consultants.

Small and newly founded firms usually use the last strategy outlined by Winch and Schneider, strong ambition. Although project complexity is low, design specificity rates high because there is less experience and fewer developed standard solutions from previous projects. This is said to be a non-sustainable strategy, and most firms end up with little ability to distinguish themselves from their competitors as they try to develop the competence to move to one of the three other strategies in Figure 2.1. According to Winch and Schneider (1993b), the problem of how to pursue this strategy also applies to established consultancy firms that try to sustain the knowledge and competence needed for this strategy, especially if they are expanding at the same time.

Depending on what strategy is chosen by an organization, the production of knowledge should turn out differently. The transfer of knowledge to the customer therefore depends on what strategy the consultancy firm has chosen. Different strategies need different kinds of interaction and learning

patterns. The knowledge management efforts within the consultancy firm therefore need various types of process support and facilitating activities, depending on how knowledge is produced.

2.2.3 Knowledge production among technical consultants

In the process of performing the detailed professional tasks, the third process identified by Maister (1982), technical consultants use their knowledge and skills to combine experience from previous projects with new knowledge and apply it to new situations in order to meet the needs of the customer as well as society. This is especially true for the two low design specificity strategies. The typical tasks in a technical consultancy firm can be said to make knowledge explicit and then to put it all together in a binder or on a compact disc where, for example, it represents a building and is available to anyone who needs access to it. Tight adherence to schedule is often critical but because consultants perform most of their work back office, they are usually free to dictate when they will do the work as long as delivery is on time. Although there is considerable interaction, documents are the primary output for the client. In building design, most client contacts are made by the architect, while the work performed by other consultants is not as obvious to many clients. It may also be difficult for a client to understand how a structural engineer or a building services engineer can add value to the client business. In spite of the tendency to co-production of services, certain types of specialized consultancy services appear to be productified black boxes (Dawson, 2000). Specialized and productified output is expected to add value to the client by enabling non-core functions to operate more efficiently, but it does not add value by transferring knowledge to the client or increasing the competence and capability of the client. Productified output can be said to imply a lower level of differentiation and can be replaced easily by services from other consultancy firms. This, in turn, would reduce the price.

Turning to recent developments in the Swedish market, many consultants try to intensify knowledge transfer to their customers in order to differentiate and compete in other ways than in terms of price. Such efforts have led them into areas such as training[4], commissioning and building operations and maintenance (see KM, 2000; SWECO, 2000; SCC, 2000). Most of the large firms have also increased their efforts in IT based areas, including GIS (Geographical Information Systems), as well as exploring areas such as FM

[4] Examples of a wider range of knowledge transfer can be found in international operations, recently analysed by Svensson (2000). Many of those projects are financed by the Swedish International Development Cooperation Agency (SIDA) and contain elements of knowledge transfer to the local client such as road administration. The consultants are not only involved in technical design, they also supervise and train the client organization how to operate and maintain the facility. This kind of assignment adds more value to the client organization than what a traditional Swedish assignment would do.

(Facilities Management). There are also examples of software production and internet services.

The output of the technical consultancy firm is often transferred from the client to a third party such as a contractor or to government authorities for approval. This puts special emphasis on the possibility for others to interpret and understand the output that has to be transferred. Output, such as documents, is to a large extent standardized in order to facilitate interpretation and understanding. Standardization of output, as described by Thompson (1967, p. 56) is a well established method for facilitating coordination, and is widely used in construction. It includes various institutional elements such as governmental regulations, formal standardization initiated by the industry (e.g. the AMA code), and the tendering system (Kadefors, 1995). Although documents may be easy to understand, only explicit knowledge is transferred to the customer. This often causes confusion because it is not always clear from the documents how the consultant was thinking when the structure was designed. A start-up meeting with the contractor is an example of mechanisms that can be used in transferring tacit knowledge from the design phase to the execution phase.

What kind of knowledge is provided and how it is packaged are therefore crucial matters for the technical consultant when intending to contribute to client value with the design of a structure. The value of knowledge depends on how it is delivered. As discussed above (section 2.1.2), Dawson (2000) asserts that greater knowledge transfer to the client will increase the value for the client. The pattern of transfer can be expected to depend on what the client buys. If the client is willing to pay a premium for expert service and high complexity or high design specificity, a larger number of cooperative events must take place where the consultant and the client learn from each other. But, if the client wants a standard solution at the lowest price, there might not be the same time or need to arrange cooperative events such as workshops, design meetings and reviews. Depending on the choice between specific expertise and standard solutions, the output is different and different kinds of knowledge will be transferred. The first example implies giving individualized expert solutions to the client problem and explains why and how the problem will be solved. The client can use the new knowledge later when dealing with similar kinds of problems. In the second example, the standard solution only solves a well known problem. Here, the client will probably not learn much from the service process, and the knowledge provided is coded in drawings and documents that are to be transferred to a construction contractor. In order to understand how knowledge can be differentiated and different kinds of knowledge can be transferred in the service process, a discussion of the knowledge concept and of learning follows.

2.3 Knowledge and knowledge management

In section 1.2 the use of the concept of "knowledge" in technical consultancy organizations was discussed. This section aims at reviewing how writers on knowledge management use the knowledge concept and to derive an interpretation of knowledge that is useful for the study of knowledge in the technical consultancy organizations. It is fruitful to distinguish between several types of knowledge. Knowledge in organizations can be understood by resorting to economic and biological analogies, which may help us in identifying the building blocks of a system for knowledge management.

2.3.1 Knowledge

Writers on knowledge management use several definitions of knowledge, see Table 2.1. At first sight, the effect is bewildering. However, if there is a common core in these attempts to define knowledge, it is probably that knowledge is seen as justified (true) belief, that the emphasis on belief implies that there is a believer, and that knowledge is related to a process, which often is thought to include human action. The definition given by Nonaka and Takeuchi (1995) appears to be the most influential one for the present generation of literature on knowledge management.

Table 2.1 Definitions of knowledge among writers in knowledge management.

Author	Definition of knowledge
Allee, (1997), p. 42	Experience that can be communicated and shared.
Brooking, (1999), p. 5	Information in context, together with an understanding of how to use it.
Davenport, Prusak, (1998), p. 5. (A pragmatic description)	A fluid mix of framed experience, values, contextual information, and expert insight that provides a framework for evaluating and incorporating new experiences and information.
O'Dell, Grayson, (1998)	Information in action.
Nonaka, Takeuchi, (1995), p. 58.	A dynamic human process of justifying personal belief toward the truth. Knowledge is created by the flow of information, anchored in the beliefs and commitment of its holder. This emphasizes that knowledge is essentially related to human action.
van der Speek, Spijkervet, (1997)	The whole set of insights, experiences, and procedures that are considered correct and true and that therefore guide the thoughts, behaviours, and communication of people.
Sveiby, (1997), p. 37	The capacity to act.
Wiig, (1993)	Truths and beliefs, perspectives and concepts, judgements and expectations, methodologies and know-how.

There are many classifications of different types of knowledge. Hærem et al. (1996, p. 119) present knowledge dimensions found in management literature as articulated or non-articulated knowledge (Itami, 1987), according to degree of embeddedness and migratory knowledge (Badaracco, 1991), tacit and explicit knowledge (Polanyi, 1962; 1966; Nelson and Winter, 1982; Nonaka and Takeuchi, 1995), transferable knowledge (Winter, 1987), and thematized or non-thematized knowledge (von Krogh and Roos, 1993).

Two major distinctions in cognitive science are also worth mentioning: between semantic and episodic memory and between declarative and procedural knowledge (Eysenck and Keen, 1992). Semantic memory refers to

our decontextualized knowledge, facts about entities and relations between entities. Episodic memory refers to knowledge about episodes and events. Declarative knowledge is related to knowing what, and procedural is tied to knowing how. Generally speaking with reference to most typologies of knowledge, there are few mutually exclusive and clear-cut categories. However, many of the typologies seem to correspond closely Polanyi's well known typology of tacit and explicit knowledge, which is also a useful typology when it comes to understand learning and transfer of knowledge.

2.3.2 Tacit and explicit knowledge

Michael Polanyi (1966, p. 4) says that we as individuals *know more than we can tell*. Polanyi calls this knowledge *tacit knowledge* because we can know things and we can do things without being able to tell anybody how we know or exactly what we are doing.

Tacit knowledge, also known as informal knowledge, is context specific and difficult to articulate and communicate. It is personal knowledge rooted in individual experience and personal beliefs, perspectives and values. Explicit or coded knowledge, also known as formal knowledge, is transferable through formal verbal or written language. Polanyi (1966, p. 4) further claims that we create knowledge by actively making and organizing experiences. Hence the knowledge that we can articulate in words and numbers only represents the tip of an iceberg.

Nonaka and Takeuchi (1995, pp. 60-61) apply the distinction between tacit knowledge and explicit knowledge. For example, knowledge of experience tends to be tacit, physical and subjective, while knowledge of rationality tends to be explicit, metaphysical and objective. Tacit knowledge is created here and now in a specific, practical context and entails what Bateson (1972) refers to as analogue knowledge. On the one hand, sharing tacit knowledge between individuals through communication is an analogue process that requires simultaneous processing of the complexities of issues shared by the individuals. On the other hand, explicit knowledge is about past events or objects there and then and is oriented toward a context-free theory. Bateson (1972) calls this sequentially created theory digital knowledge. Thus, the dichotomy of knowledge into tacit and explicit knowledge also refers to the accessibility of knowledge. It is assumed that tacit knowledge is not as accessible as explicit knowledge and that it is therefore more difficult to transfer.

2.3.3 Knowledge, information and data

Most authors use a distinction between knowledge and information when discussing knowledge management. A firm that sells standardized packages of information relies on intangible assets just as much as a technical consultancy firm does. However, the output from the technical consultancy firm is solutions to problems, and the customers do not usually want the same advice twice, at least not at the same price. Customers must therefore be treated as individual entities, which has important implications for the choice between economies of scale and of scope. In the case of standardized services, the driver is said to be information but in the customized case the driver is knowledge (Armistead, 1999; Sveiby, 1997, p. 24).

Much of the business of technical consultants can be characterized as trivial but not standardized, although some projects may contain a smaller proportion of standardized components, in other words a higher degree of design specificity. Management of information is not enough. Technical consultants must learn to manage knowledge in order to increase their competitive strength. Therefore, it is fruitful to distinguish between information and knowledge, and several authors (Alter, 1996; Allee, 1997, p. 62; Tobin, 1996; van der Speek and Spijkervet, 1997; Davenport, 1997) also draw distinctions between data, information and knowledge. Some authors[5] even go beyond knowledge to an evolutionary learning process of knowledge, see Table 2.2.

Table 2.2 Concepts related to knowledge.

Alter (1996)	Davenport (1997)	Tobin (1996)	Beckman (1997)	Allee (1997)
Data	Data	Data	Data	Data
Information	Information	Information	Information	Information
Knowledge	**Knowledge**	**Knowledge**	**Knowledge**	**Knowledge**
		Wisdom	Expertise	Meaning
			Capability	Philosophy
				Wisdom
				Union

However, many authors (among them Davenport, 1997) find it rather difficult to operationalize the distinctions between data, information and knowledge. Nonaka and Takeuchi (1995, p. 58) try to see the difference between information and knowledge as if information is a flow of messages, and knowledge is what is created by that very flow of information, anchored in the beliefs and commitment of its holder. Starbuck (1996, p. 487) attempts to clarify the distinction by defining knowledge as a stock of experience rather than a flow of information. Thus he suggests that knowledge relates to information in the same way assets relate to income. The distinction between

[5] Especially Allee, 1997, who devotes her book to exemplifying and explaining how to advance in her hierarchy of knowledge.

information and knowledge is thereby understood as the degree to which information is processed and put into a practicable context.

Davenport (1997, pp. 9-10) asserts that data are simple observations of states of the world. Data are easily structured, captured on machines, often quantified and easily transferred. He further uses Drucker (1988b) to define information as data endowed with relevance and purpose. Information requires units of analysis, needs consensus on meaning and also human mediation. Davenport (1997) says that knowledge consists of valuable information from the human mind. It includes reflection, synthesis and context and is said to be hard to structure, difficult to capture on machines, often tacit and difficult to transfer. However, it can be embedded in machines (Davenport, 1997) as well as in technology and routines (Argote, 1999, pp. 90-93).

Brown and Duguid (2000, pp. 119-120) note that the terms 'knowledge' and 'information' are often interchangeable in literature. However, they also note three generally accepted distinctions between the terms. First, they mention that knowledge usually entails a knower. Given this personal attachment, knowledge secondly appears harder to attach than information while information is easy to find, possess, put in a database, accumulate, compare, and so forth. Knowledge, in contrast, is less easy to pin down. Their third distinction is that knowledge seems to be something we digest rather than merely hold. Brown and Duguid assert that it entails the understanding of the knower and some kind of commitment. They say that information can be conflicting but knowledge is usually not. Brown and Duguid further state that it is reasonable to say: "I have got the information, but I do not understand it" rather than "I know, but I do not understand." These three distinctions between knowledge and information should initiate a shift from processes and technology towards people and the assimilating, understanding and sense making of information. Unless the social human process of shared understanding and sense-making of information is in place, it cannot be converted to knowledge.

It can be concluded that knowledge can be transferred either directly between individuals through socialization, or indirectly by delivering information which people can make meaning of and internalize as their personal knowledge. Information, in turn, is data that have been put in context.

2.3.4 Building stocks of knowledge

Knowledge is developed through learning from education and by learning in daily work. The development of knowledge can be said to be a question of interplay between tacit and explicit knowledge (Nonaka and Takeuchi, 1995,

p. 73), and it grows from sharing. The “stock” of knowledge does not diminish if it is shared with others. On the contrary, if it is sold in an assignment, for example as a consultant service, the knowledge provider will probably learn something new from the people involved in the service process.

On a fundamental level, individuals create all knowledge. The organization cannot create knowledge or learn by itself, strictly speaking. Instead, it supports creative individuals or provides contexts in which they can create, and transfer knowledge (Nonaka, Takeuchi, 1995, p. 59). Creating and transferring knowledge can, according to Nonaka (1994), be understood in terms of a process that organizationally amplifies the knowledge created by individuals, and develops it into a part of the knowledge network of an organization.

Every business develops its own collection of conceptions. As members of the same business (or profession: e.g. computer specialists, dentists, fishermen, surgeons, technical consultants) talk to each other, they use technical jargon incomprehensible to outsiders. Mastery of this jargon is referred to as a part of the competence needed to become a full member of the profession (Lundequist, 1995, p. 29). It is an expression of knowledge accumulated in the individuals as well as for the whole business. Most is stored as tacit knowledge in the heads of individual but some is written down and presented as explicit knowledge, e.g. in manuals and handbooks. There is a trade off between how much knowledge can be explicit and how much has to be tacit. The next section takes up the thread left by the introduction of knowledge management in section 1.5.1, and discusses how organizations can manage knowledge.

2.3.5 Two leading approaches to knowledge management

Analogies have proven to be of great value for understanding organizations (Morgan, 1986; Palmer and Dunford, 1996). In the area of knowledge management there are two prevailing approaches that can be illustrated by the analogies of economics and biology (Ponelis and Fairer-Wessels, 1998). The economic analogy refers to accumulated knowledge as intellectual capital, an extension of the concept of capital[6]. This analogy is represented in the literature by Brooking (1996); Edvinsson and Malone, (1997); Sveiby (1997); and Roos et al., (1998). Although managers favour the economic analogy it has met with criticism and sometimes it is said to be limited and not entirely appropriate. Knowledge creation is not the same as labour, and knowledge

[6] The analogy with capital also underlies discussion of resources in the professional service organization (see section 2.1.3).

assets are not the same as physical assets, goes the reasoning. According to the position taken by Brown and Duguid (2000, p. 150) on the economic analogy, knowledge is critical, and there is a problem concerned with its movement it is difficult to stop, which leads then to use a physical analogy. Like water, knowledge flows, or more accurately leaks, out of the organization, and intellectual property laws are almost powerless to stop it.

The biological analogy considers the organization an organism where the accumulated knowledge is referred to as a corporate memory. This analogy is supported by the metaphor of information as life-blood and the system through which information is distributed as the circulation system. Thus information keeps the organism (organization) alive but in itself it does not initiate actions like knowledge in the brain of the individual does. The theories of the learning organization build on the biological analogy. Using also this approach to knowledge management, Brown and Duguid (2000) again refer to knowledge as critical, and again they see a problem concerned with its movement. However, the movement problem is now a problem of inertia: it is that knowledge is difficult to move to where it is needed.

As the present investigation is intended to shed light on knowledge management initiatives and on how knowledge is transferred, theories springing from the biological analogy will also be used here. In focusing on the organism (organization), it is of interest to ask where knowledge is stored (sources) and how it can be acquired or retrieved and made accessible to the entire organization.

2.3.6 Practical models for introducing knowledge transfer

There are many examples available of how knowledge management has been introduced in organizations. One frequent approach is to start with a small pilot project, which, it is hoped, will be a success that can be related to as further projects start up (O'Dell and Grayson, 1998, pp. 21-26). Another approach is to build knowledge maps, making it possible to at least find out who knows what. Sarvary (1999) thinks that there are, in general, two approaches to building a system for knowledge management: bottom-up, decentralized systems focusing on people; and top-down, centralized systems focusing on technology support. Savary's approaches are similar to the knowledge management strategies presented in section 1.5.2.

According to Dash (1998), successful systems for knowledge management involve more than merely deploying the newest and fastest IT products, which until recently was a common thought in magazines[7] writing about

[7] Such as Knowledge Management Magazine, KM World, and Fast Company.

knowledge management for practitioners. Similarly, most of the leading consultancy firms and practitioners in knowledge management state that it consists, in addition to technology, of processes and people[8]. With regard to computer consultancy firms providing what they call knowledge management solutions technology driven projects are still most common, but recently the focus has begun to shift towards people and organization driven knowledge management projects. The emphasis on people in the knowledge management literature is clear, and this forms the basis for attempts to differentiate it from other management disciplines, in particular information management.

> Managing knowledge starts with stressing the importance of people, their work practices and culture, before deciding whether or how technology should be brought into the picture. Information management, on the other hand, often starts with a technological solution first - with consideration of people's work practices and work culture as a distant second. (Holtshouse, 1998)

Following the thoughts presented in his seminal paper (Wiig, 1997c), Wiig (1999) introduced a complicated but well-structured model of how to introduce and sustain knowledge management practice in an organization. The model represents a systematic consultant's perspective on knowledge management, and it is particularly interesting because it points out the variety in what practicing consultants include in knowledge management. He suggests that the organization builds a system of blocks, interconnected activities for knowledge management that support each other in a functional manner. Moreover, he points out that the organization may focus on a limited number of blocks and expand step by step, moving from implementation to administration. The model proposed by Wiig and reproduced in Figure 2.2 is one of the most highly developed in the knowledge management literature, as it covers both strategic and operative aspects in some detail.

O'Dell and Grayson (1998) assert that many organizations start to organize their knowledge management efforts by focusing on identifying, collecting and organizing their best practices and internal knowledge (see Table 2.3). In studying various models of the knowledge transfer process, it is obvious that there should be much to be gained by helping organizations to "know what they know".

[8] At the Strategic Planning Society's conference for practitioners on knowledge management (London, November 1998), most of the speakers (among others representing CAP Gemini Management Consultants and KPMG Management Consulting) emphasized dealing with people as the most important issue for knowledge management. This is not an isolated example.

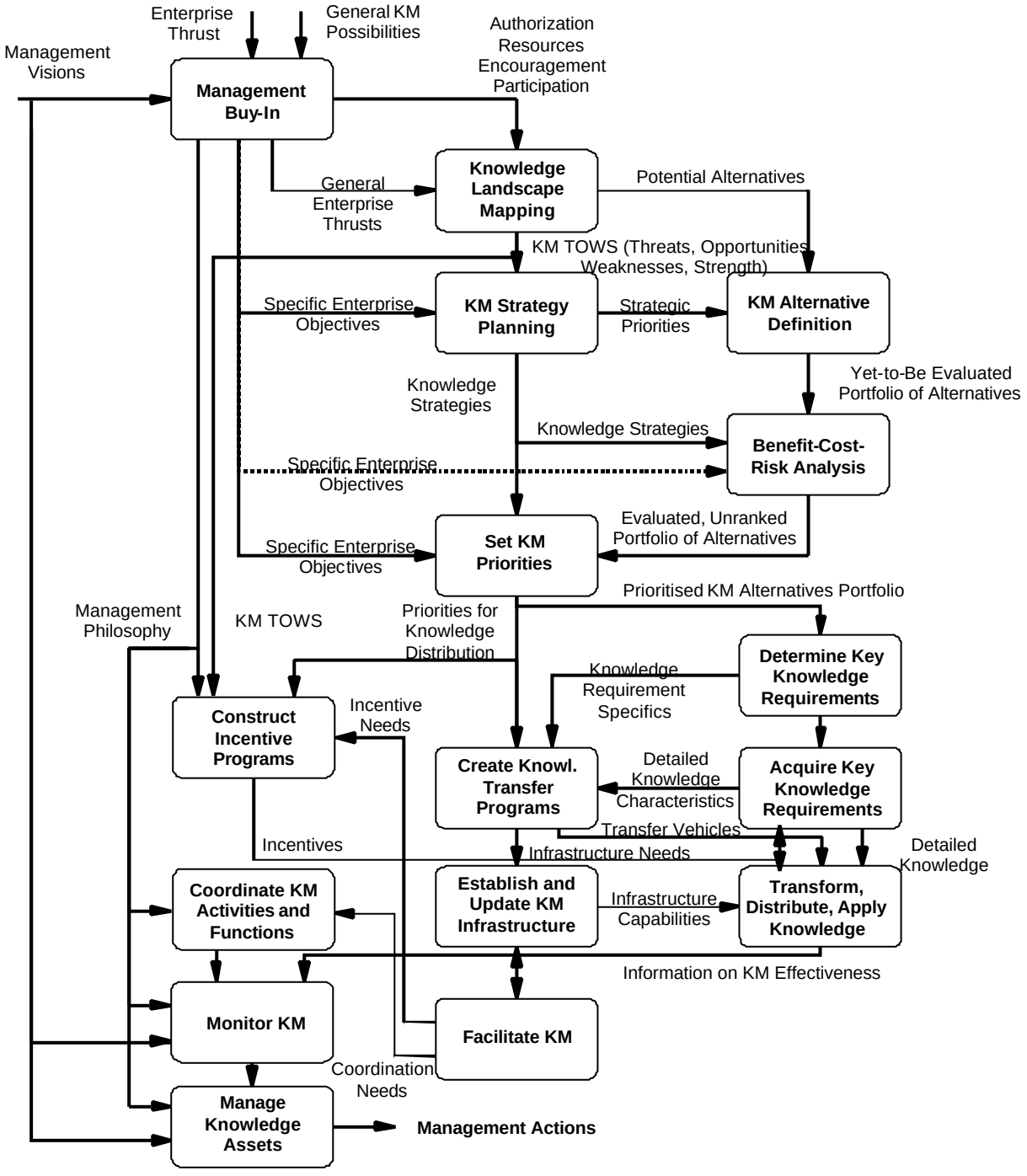

Figure 2.2 Relationships between knowledge management building blocks (Wiig, 1999).

Obviously the process does not end with organizing knowledge. It then has to be shared, adapted and used before new knowledge can be created by experience and start a new cycle. Most process models have names associated with large management consultant firms such as Arthur Andersen, KPMG Consulting, Cap Gemini and Renaissance Worldwide. O'Dell and Grayson's model was developed at the American Productivity and Quality Centre

(APQC) (O'Dell and Grayson, 1998). The process proposed by O'Dell and Grayson (1998, pp. 24-26), developed at APQC is facilitated by four enablers: culture, technology, infrastructure and measurement. An almost identical model (included in the Knowledge Management Assessment Tool, KMAT) was developed by APQC in co-operation with Arthur Andersen, see Table 2.3 (Allee, 1997, p. 48). This model of the knowledge transfer process consists of adapting, collecting, identifying, creating, sharing, applying and organizing knowledge. The three activities of collecting, identifying, and organizing pertain to managing and building a body of knowledge. Creating, sharing, applying, and adapting refer to activities for creating and renewing such knowledge. The process is in this case said to be facilitated by technology, culture, leadership and measurement, almost the same facilitators as in the model of O'Dell and Grayson.

Table 2.3 Stages of a knowledge transfer process as proposed by management consultants.

Arthur Andersen and APQC (Allee, 1997)	KPMG Consulting (KPMG, 1998)	Gap Gemini (Cap Gemini, 1998)	Renaissance Worldwide (Cliff, 1998)	APQC, O'Dell, Grayson (O'Dell, Grayson, 1998)
Collect	Create	Creating	Observation	Create
Identify	Encapsulate/Record	Embedding	Shared insight	Identify
Create	Source	Distributing	Knowledge development	Collect
Share	Exploit	Using	Knowledge representation	Organize
Apply	Apply		Knowledge publishing	Share
Organize	Learn		Distribution	Adapt
Adapt	(Share/Disseminate)		Performance	Use

The other three consultancy models of the knowledge transfer processes listed in Table 2.3 are similar to those developed by O'Dell and Grayson and by Allee. The roots of these process models can be found in the literature of organizational memory and organizational learning and information management to be discussed below in section 2.6.1.

Although there are many interpretations of the knowledge transfer process, it is clear that creation and transfer of knowledge is seen by leading knowledge management consultants as a process performed in an organization as a part of the business process and usually supported by information technology based tools. There are various ways in which an organization can support the knowledge transfer process. Organizational and technological efforts can, according to Davenport and Prusak (1998, p 155) as well as Zack (1999), contribute differently to various sub-processes in the knowledge transfer process, and also support transfer of different kinds of knowledge.

In management literature, the process of transferring knowledge, when once implemented, is usually referred to as a circular feedback loop (Nevis, DiBella, and Gould, 1995; Allee, 1997; O'Dell and Grayson, 1998). Its aim is to find knowledge, sometimes by creation of new knowledge and sometimes by locating existing knowledge in lessons learned, and preparing it for reuse and transfer to whoever has permission to use it. Such a knowledge transfer

process is similar to learning processes such as the well known PDCA (Plan-Do-Check-Act) cycle presented by Deming (1986). Before pursuing this topic, it will be necessary to consider learning.

2.4 Organizational learning

Researchers in the field of organizational learning have provided us with many definitions of individual and organizational learning (for a still valuable overview and critical comments, see Garvin, 1993). What is a learning organization? Nonaka (1988) asserted that the learning organization

> … transforms the flow of information into a stock of knowledge and, at the same time, spreads it to other departments and stimulates the systematic self-organizing of information. (Nonaka, 1988, p. 70)

Knowledge generated by changing groups of individuals might be gradually shared by the members of the organization and in that sense becomes knowledge at the organizational level. But is it necessary to require that every employee shares this knowledge? Learning is, according to Schein (1996b), a basically individualistic concept drawn directly from psychology, where it is highly developed. He further claims that there is no good definition of what it might mean for an organization to learn. Argyris and Schön (1996) look at this issue in detail, arguing that when individuals are in organizational roles acting on behalf of their organizations, their learning can be thought of as organizational learning. By contrast, Cook and Yanow (1993) argue persuasively that organizations have to perform as total organizational units, and their ability to do so under changing environmental conditions can be legitimately thought of as organizational learning. The literature on learning organizations often views the organization as if it were an individual, and organizational learning is assumed to be roughly similar to individual learning. Although this is a position that might not convince everybody, an understanding of individual learning should nevertheless be a useful starting point to describe organizational learning.

2.4.1 Individual learning and mental models

Individual thoughts appear to be based on cognitive inner structures, which consist of the individual's fundamental assumptions about reality. Johnson-Laird (1983), Senge (1990) and Kim (1993) all call these inner structures of memory mental models[9]. Mental models are large, complex mental structures

[9] These are also discussed by other authors under various names such as cognitive schema, mental representation, mental map, and knowledge structure (Isenberg, 1986). For an extensive review of mental models and organizational cognition, see Walsh (1995).

of knowledge that have been inferred from past experience, and they are ascribed three purposes. First, to evaluate experience. Second, to store new and processed knowledge. To store new knowledge means either adding to the individual's existing knowledge or modifying the individual's existing knowledge. Third, to guide the actions of individuals.

The learning process does not need to be conscious or intentional, nor does it always increase the effectiveness of the learner or result in observable changes in behaviour. Instead, learning means that an individual learns through acting on the basis of its mental models, processes information, makes experiences from these actions, modifies its models, and as a result the range of its potential behaviour is changed (Huber, 1991). Modification of mental models has to be linked to the individual interpretation of events and action, described by Daft and Weick (1984) as a process through which people give meaning to information. In this sense, an individual learns through developing different interpretations of new or existing information and thereby developing a new understanding of the environment (Fiol, 1994).

2.4.2 Organizational learning and shared mental models

In small organizations, individual and organizational learning are almost the same. As the organization grows, a distinction between individual and organizational learning emerges and a system for capturing knowledge of the individuals may evolve. The second level of learning, above the individual level, is the group level. As people talk they share new knowledge and use it together. Sometimes this knowledge permeates the whole organization and the learning that occurs at a lower level is reflected in the actions of the organization, which is when learning on the organizational level has occurred.

According to an early, and still useful classification, research in organizational learning can be summarized in four distinct and contrasting perspectives: (1) adaptive learning, (2) institutionalized experience effects, (3) assumption sharing and (4) development of a knowledge base (Shrivastava, 1983).

The adaptive learning perspective is characterized by the view that organizations adapt to changes in the environment by readjusting their goals, attention rules and search rules. This perspective was originally formulated by Cyert and March (1963), and was further developed by Cangelosi and Dill (1965). March and Olsen (1975) made a crucial distinction between individual and organizational action in their model of organizational learning. Individual actions are based on individual beliefs, which are similar to the mental models of the last section. These actions, in turn, lead to organizational actions that produce environmental responses. The cycle is complete when response affects individual beliefs.

More recently, Levitt and March (1996) build an interpretation of organizational learning where organizations can be seen as learning by encoding inferences from history into routines that guide behaviour. The two authors use the generic term routine as including the forms, rules, procedures, conventions, strategies and technologies around which organizations are constructed and through which they operate, as well as the structures or beliefs, frameworks, paradigms, codes, cultures, and knowledge that buttress, elaborate, and contradict the formal routines. Routines can thereby be seen as a platform where organizational knowledge is stored, and seem to be similar to what Huber (1991) calls organizational memory in his extensive review of the organizational learning literature (see section 2.6.2).

Most studies of organizational learning appear to assume that the result of learning is changes in action patterns (e.g. March and Olsen, 1976; Duncan and Weiss, 1979; and Hedberg, 1981). Cognitive changes in the organization and changed behaviour that leads to non-reactive action patterns also exist but they are quite rare in the literature (see for example: Hedberg, 1981; Brunsson, 1985; and Müllern and Östergren, 1995).

The second perspective, that of institutionalized experience effects, was originally formulated by psychologists at the end of the nineteenth century (Argote, 1999, p. 4). Later the Boston Consulting Group (1968) found that learning curve effect could be extended to managerial decision-making. Albernathy and Wayne (1974) and Yelle (1979) also contributed to this perspective. Recently Argote (1999) has written an overview of this perspective and its development.

In the third perspective, assumption sharing, Argyris and Schön (1978) have presented a theory where organizational learning takes place through individual members whose actions are based on theories-in-use, resulting from sharing assumptions and cognitive maps among organizational members. The construction and modification of these theories-in-use through individual and collective inquiry is what Argyris and Schön call organizational learning.

Learning has been considered a change in mental models. Argyris and Schön (1978) call this challenge to and change of deeply rooted assumptions double-loop learning. They also present single-loop learning. Single-loop learning corrects or changes the way people work without changing their more deeply rooted assumptions or radically changing their routines. New knowledge is assimilated into previously existing knowledge. One result of this might be an ability to carry out the same task better or faster without questioning the underlying norms such as shared mental models. Argyris and Schön build on the assumption that learning takes place on different intellectual levels and

that learning is triggered by a detection or correction of errors (Argyris, Schön, 1978)[10].

A group or an organization can then (according to Kim, 1993) be interpreted as a collective individual, with its own set of mental models that contribute to the organization's learning and its shared mental models. According to Cannon-Bowers et al. (1993), who have contributed an extensive review of the literature on the topic these can be defined as knowledge structures held by members of a team that enable them to form accurate explanations and expectations for the task, and in turn, to coordinate their actions and adapt their behaviour to demands of the task and to other team members. Shared mental models can, according to Lyles and Schwenk (1992) who use the term organizational knowledge structures, differ from individual mental models (personal schemata) because they are socially constructed and rely on consensus or agreement. Kim (1993) further assumes that organizational learning takes place as individual routines that have proved to be sound over time become embedded in the organizational routines. Changes in the shared mental models occur as a result of the impact of the interpretation of environmental events, result of past organizational actions, the influence of decision-makers, and the advocacy position of coalitions within the firm (Lyles and Schwenk, 1992).

Many authors (Duncan and Weiss, 1979; Hedberg, 1981; and Kim, 1993), emphasize organizational learning as being more than the accumulated knowledge of the individuals within the organization.

> Although organizational learning occurs through individuals, it would be a mistake to conclude that organizational learning is nothing but the cumulative result of their members' learning. Organizations do not have brains, but they have cognitive systems and memories. As individuals develop their personalities, personal habits, and beliefs over time, organizations develop word views and ideologies. Members come and go, and leadership changes, but organizations' memories preserve certain behaviors, mental maps, norms, and values over time. (Hedberg, 1981, p. 6)

Hedberg's point is that knowledge can be embedded not only in human capital, as discussed earlier in section 2.1.3, but also in the structural capital of the organization.

The fourth perspective on organizational learning, development of a knowledge base, is characterized by learning seen as the process by which knowledge about action-outcome relations is developed. Duncan and Weiss

[10] A third level, called deutero-learning, was originally proposed by Bateson (1972), and later discussed in Argyris and Schön (1978). When an organization engages in deutero-learning its members learn about previous contexts for learning, i.e. they learn how to learn.

(1979), contributing to this knowledge base perspective, connect individual knowledge to organizational knowledge in a learning process that specifies three criteria that must be fulfilled. Knowledge must be exchanged and shared with others to become organizational, knowledge must be evaluated by others, who also share that knowledge, to become organizational, and it must be integrated with other related knowledge to become organizational knowledge. Duncan and Weiss thus define organizational learning as a process, and not as an outcome:

> Organizational learning is defined as the process within the organization by which knowledge about action-outcome relationships and the effect of the environment on these relationships is developed.

The process of organizational learning can thus be understood as a process where the shared mental models change continuously as the organization acquires more knowledge and experience through learning. More recently, two influential overviews of the literature on organizational learning (Huber, 1991; Dixon, 1992) have contributed with categorizations of the literature into constructs respectively areas that constitute sub-processes in the process of organizational learning. Hence, the knowledge base perspective sees learning more as a process, in which knowledge can be managed. As this investigation aims to study how knowledge is managed it is reasonable to use the knowledge base perspective of organizational learning. Before the more detailed review of what can be considered as a process perspective of managing knowledge, it will be necessary to return to the dichotomy of tacit and explicit knowledge.

2.5 The social process of creation and transfer of knowledge

Creating and maintaining knowledge is a process of sharing both tacit and explicit knowledge between individuals in an organization. The transition from tacit to explicit knowledge is necessary to make knowledge communicable, which is important for learning as well as for transfer of knowledge. A problem known as the communication skill gap is that people are aware that they know but incapable of expressing their knowledge to others (Bukowitz, 1998). Molander (1993, p. 17) mentions that such a skill gap has traditionally been overcome by training and practising under the supervision of an expert. That the master and the pupil reflected together about techniques, tools, instruments, and goals. At the end the pupil accessed personal entry into the tradition.

This is actually the extensive theory of creation and transfer of knowledge presented by Nonaka (1994) and further developed by Nonaka and Takeuchi (1995). The model describes a social process as a never-ending spiral of tacit

and explicit knowledge through four modes of *knowledge conversion*, *socialization* (tacit to tacit), *externalization* (tacit to explicit), *combination* (explicit to explicit) and *internalization* (explicit to tacit), see Figure 2.3. One critical assumption is thus that knowledge is created and transferred through a social process between individuals and through the interaction between tacit knowledge and explicit knowledge (Nonaka and Takeuchi, 1995, p. 61).

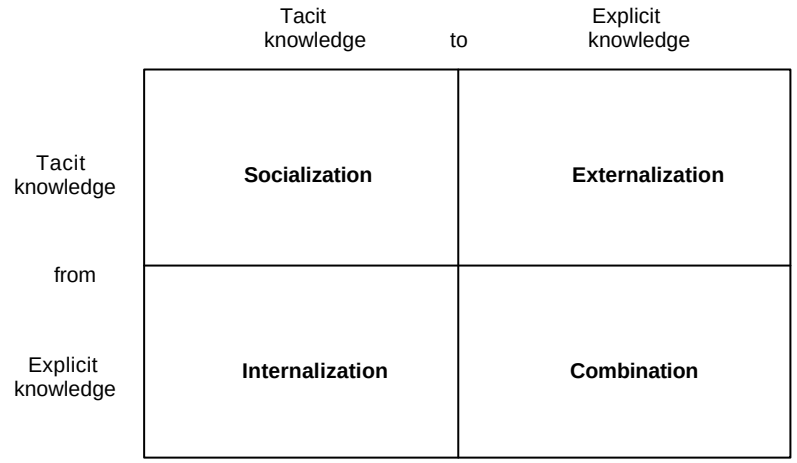

Figure 2.3 Four modes of knowledge conversion. (Source: Nonaka and Takeuchi, 1995, p. 62)

Three of these four modes of knowledge conversion have been widely discussed in organizational theory. Nonaka and Takeuchi (1995, p. 61) point out that socialization is related to theories of group processes and organizational culture; combination has its roots in information processing; and internalization is closely related to the previously discussed organizational learning. Nonaka and Takeuchi consider the mode of externalization as having a less obvious link to any particular school of thought.

2.5.1 Socialization: group theory and organizational culture

Tacit knowledge can be gained from other individuals through a process of watching, imitating an existing process and experience sharing, called socialization. Even very complex knowledge that is difficult to express can be shared through socialization. According to Nonaka et al. (1996) the process of socialization is a limited form of knowledge creation and transfer in itself. Although it is a successful way of transferring tacit knowledge from one individual to another, only a limited number of individuals can be involved at the same time, which is not enough for large organizations. Teaching craftsmanship skills and on the job training are based on the principle of socialization. An individual can learn tacit knowledge through socialization without a language. However, language certainly facilitates learning (Molander 1993, p. 42).

An example of socialization is when team members work together. Teams are a substantial part of a learning organization. Peter Senge (1990, pp. 233-269) points out team learning as one of the five disciplines a firm has to master on its way to becoming a learning organization. Effective teams include people from different backgrounds and with different and complementary skills. They can learn from each other while performing a team task. The learning takes place through socialization when they work close together, as well as during the many team conversations that take place as the team goes through the processes of externalization and combination. Knowledge transferred by communication can then be applied directly to the team task and be internalized.

2.5.2 Externalization

In order to communicate tacit knowledge, it has to be transformed into explicit knowledge. Nonaka and Takeuchi (1995, p. 64) call this externalization, and see it as the essential step in the knowledge conversion process. Meaningful dialogue and collective reflection using metaphors and analogies (see Morgan, 1986) help to create an explicit model. A consultancy firm such as Arthur Andersen introduced a basic set of journalism and publishing skills to facilitate such communication (Bukowitz, 1998).

2.5.3 Combination and information processes

Explicit knowledge gained from externalization can then be combined to create systemic explicit knowledge as it is communicated to others and merged with their knowledge. Media used in this process include common discussion at a meeting or training session as well as documents, telephone calls, or digital networks. During this process, knowledge is systematized and categorized into the collective explicit knowledge framework of the organization[11]. Patents, written rules and procedures, organizational charts and similar documents are examples of such knowledge. Combination mainly serves the purpose of integrating the knowledge into the organization's knowledge base and distributing it throughout the organization. However, it has to be emphasized that combination of one kind of knowledge with another can lead to the creation of new knowledge. Creative uses of computerized communication networks and databases, such as sorting, adding, combining and categorizing knowledge, facilitate this mode of conversion (Nonaka and Takeuchi, 1995, pp. 67-68).

[11] organizational memory according to Dixon (1992), see Chapter 2.6.2.

2.5.4 Internalization and organizational learning

Internalization is the conversion process of transforming explicit knowledge into (operational) tacit knowledge. Experiences become valuable assets as they become operational in a new context and are internalized into tacit knowledge bases of individuals in the form of mental models. Having the knowledge verbalized or graphically represented in documents and manuals facilitates the transfer of explicit knowledge to tacit knowledge. Documentation helps individuals to internalize what they or others have experienced. The process is a part of organizational learning and especially learning by doing, related to the first two perspectives of organizational learning discussed in section 2.4.2: adaptive learning and institutionalized experience effects. For organizational knowledge creation to take place, tacit knowledge accumulated at the individual level needs to be socialized in the organization, possibly starting a new spiral of knowledge conversion.

2.5.5 Creation and transfer of knowledge through a cyclic process

Organizational knowledge creation and transfer can be viewed as a process whereby the knowledge held by individuals is amplified and internalized as part of an organizational knowledge base (Nonaka, 1994). As knowledge is transformed from an individual to a collective state, organizational knowledge is created (Nonaka and Takeuchi, 1995, p. 72). The transformation occurs in a dynamic process involving various organizational levels and carriers of knowledge. Specific learning processes are at work at each level. At the individual level, the critical process is interpreting and sense making; and at the group level it is integrating; and finally at the organization level it is integrating and institutionalizing (Inkpen and Crossan, 1995; Inkpen and Dinur, 1998). Knowledge has been transferred in a cycle from one level to another. The learning cycle is then repeated several times and a knowledge spiral for organizational knowledge creation and transfer is created.

In transferring knowledge the interplay between tacit and explicit knowledge is thus essential. Most knowledge in organizations is tacit in the form of knowledge from experience (see section 2.3.2). Transfer of tacit knowledge by first making it explicit is therefore a process that needs to be facilitated in knowledge intensive organizations (Nonaka and Takeuchi, 1995, p. 73). This process has to be systematic and its results have to be presented in a systematic way in order to facilitate combination and internalization, which are necessary for success in transferring knowledge. Transfer of knowledge not only includes combination or sharing and adaptation (as it is expressed in the knowledge management terminology used by O'Dell and Grayson, 1998, see section 1.5.1), it also includes the use of knowledge. Knowledge management applies systematic approaches to find, understand, and use

knowledge to create value (O'Dell and Grayson, 1998, see section 2.3.6). Knowledge management can therefore be seen as a knowledge transfer process and a deliberate way of learning in combination with other action that facilitate this process. The next section returns to this transfer process before facilitating is discussed.

2.6 Knowledge management as a learning process

Learning can be referred to as a cyclic process in at least two major ways: first by bringing tacit knowledge of individuals into explicit organizational knowledge and secondly by transferring knowledge to others in their daily work. Both these cyclic processes are a matter of learning and transfer of knowledge and can be included in the process of managing knowledge. As suggested by Sarvary (1999) knowledge management can be seen as a business process integrated with other business processes such as the project management process (see section 1.5.1).

2.6.1 Models of the knowledge transfer process

In section 1.5.1 four perspectives on knowledge management as a process were presented, and in section 2.3.6 five practical models of the knowledge transfer process with connections to management consulting were reviewed. The aim is now to go behind those models to explanatory models that stem from more established academic research traditions. Early approaches to the process of creation and transfer of knowledge can be found in the literature on organizational memory (Stein, 1989; Walsh and Ungson, 1991) and organizational learning (Huber, 1991; Dixon, 1992), where the focus is on memory and particular sub-processes in the processes of organizational memory and organizational learning (see Table 2.4). Walsh and Ungson (1991) assume that the sub-processes for organizational memory are acquisition, storage, and retrieval of information. Stein (1995) asserts that organizational memory concerns the knowledge base of the organization and the attendant process that changes and modifies that base over time. He further asserts that the process of memory consists of knowledge acquisition and learning, knowledge retention, knowledge maintenance and finally knowledge retrieval. Huber (1991) describes four learning related constructs similar to what Walsh and Ungson, and Stein call organizational memory and that contribute to organizational learning: knowledge acquisition, information distribution, information interpretation, and organizational memory. Following Huber, but with extra emphasis on retrieval of information, Dixon (1992) proposes a more detailed model of the organizational learning process, which also includes activities or methods.

Table 2.4 Sub-processes of cognition, organizational learning, organizational memory, and knowledge transfer.

Author	Sub-processes						
Argote (1999)	Sharing and generating new knowledge			Evaluating knowledge	Combining knowledge		
Bartezzaghi et al. (1997)	Abstraction and generalization		Embodiment	Dissemination			Application
Despres and Chauvel (1999)	Mapping	Acquire Capture Create	Package	Store		Apply Share Transfer	Reuse Innovate Evolve Transform
Dixon (1992)	Information acquisition		Information distribution	Information interpretation	Making meaning	Organizational memory	Information retrieval
Huber (1991)	Knowledge acquisition		Information distribution	Information interpretation		Organizational memory	
Nevis et al. (1995)	Knowledge acquisition		Knowledge sharing				Knowledge utilization
Stein (1995)	Knowledge acquisition and learning		Knowledge retention		Knowledge maintenance		Knowledge retrieval
Walsh, Ungson (1991)	Information acquisition			Information storage			Information retrieval
Wiig (1997b)	Knowledge creation		Knowledge capture	Knowledge transformation			Use

Based on theories of group learning Argote (1999, pp. 105-126) proposes a process where a group begins to acquire knowledge by sharing knowledge or generating new knowledge. Once knowledge has been shared or generated it must be evaluated to determine its accuracy and appropriateness. Various bits of knowledge then have to be combined into a collective product of knowledge available to use, according to Argote. Bartezzaghi et al. (1997) assume that such learning in one project can be transferred to other projects through a stable framework of hypotheses about relationships[12] in which transfer of knowledge is facilitated and oriented as described earlier by Prahalad and Hamel (1994). Bartezzaghi et al. (1997) have also proposed a learning process to this end, consisting of abstraction and generalization, embodiment, dissemination, and application of learning.

Nevis, DiBella and Gould (1995) suggest another variation, also in terminology, of the organizational learning process presented as a learning cycle. They link knowledge to learning in a three-stage process consisting of (1) knowledge acquisition where skills, insights and relationships are developed or created; (2) knowledge sharing that includes dissemination of what has been learned; and finally (3) knowledge utilization where learning is integrated into the organizational knowledge base so it is broadly available and can be generalized to new situations. The organizational learning process, described by Nevis et al., resembles models of the knowledge transfer process developed by management consultants in cooperation with academics (see section 2.3.6), especially the model of Davenport and Prusak (1998). The most obvious difference is that what Nevis et al. call acquisition is just one part of

[12] known as meta-models, not unlike the organizational knowledge base.

what Davenport and Prusak (1998, p. 52) include in their concept of knowledge generation.

Despres and Chauvel (1999) have outlined their process of cognition as an event chain similar to the models presented in section 2.3.6. While their representation of the process greatly simplifies the interconnected and multiple-causal nature of cognition, they admit that it appears to fit many of the issues addressed according to a time-process perspective of knowledge management. Their first sub-process, event mapping, is a survey of business intelligence and perception of the business environment. The world of research, development and creation is related to the second sub-process: acquire, capture, and create. Packaging refers to the world of codification and representation and storing refers to organizational memory. Applying, sharing, and transferring next refers to competencies, teamwork, intranets, and cross-border sharing. Finally reusing, innovation, evolution, and transformation refers to the world of intellectual assets, innovation, and to using knowledge.

The perspectives on managing knowledge and information, such as managing a memory and learning, presented here may seem influenced by logistics. Although they are not identical, most processes of knowledge management, organizational learning and organizational memory appear similar if the sub-processes are analysed at the activity level, which is easily found by looking at Table 2.3. These authors build on the assumption that knowledge can be acquired or retrieved, distributed, interpreted and analysed before it can be stored for later use in new situations.

Dixon's (1992) human resource development perspective (evolved from the management perspective of Huber, 1991) coincides with the knowledge base perspective of organizational learning and is well structured, well explained and fits well into the aim and research questions of this investigation. There are two main reasons for choosing the process model proposed by Dixon as a basis for continued discussion. The first is that it is possible to test and measure some of the sub-processes on a population, especially activities. It is assumed that a such a process view can contribute to the first research objective, studying how knowledge is transferred in technical consultancy firms. It is also easy to understand and describe how various process support tools can contribute to the sub-processes in Dixon's process model. This is also assumed to be valuable when discussing issues related to the second research objective of this investigation: "What is the role of process support tools in enabling transfer of knowledge within technical consultancy firms?". However, the sub-process of information interpretation in the model of Dixon is a source of ambiguity within the model. Information interpretation is said to follow after information has been distributed and then information interpretation is said to occur once again in the sub-process of making

meaning. To avoid this reappearance of interpretation, the model that will be used in this investigation will be slightly modified so that the sub-process of information interpretation will be included only in the sub-process of making meaning. The model will therefore resemble the original model proposed by Huber (1991) in this respect and on which Dixon based her model.

2.6.2 The learning and knowledge transfer model developed

A more operative and detailed model of the knowledge transfer process containing five sub-processes can now be presented. It is to a large extent based on the division of organizational learning into six major sub-processes made by Dixon (1992) (see Table 2.4). The sub-processes can be viewed as sequential, but Dixon assumed that there would be overlap based on the results about how organizations learn presented by Daft and Weick (1984). Dixon asserted that, rather than being sequential, organizational learning sub-processes appear to be continuous and have an interaction effect upon each other. She further exemplified this with information distribution, occurring through different channels, each having different time frames.

Knowledge and information acquisition

Learning occurs when an organization acquires knowledge. Acquisition of knowledge and information is achieved by monitoring the environment, using information systems to store, manage, and retrieve information, carrying out research and development, education and training, patent watching, and bibliometrics (Dodgson, 1993). Learning occurs not only on the basis of knowledge acquisition from the external environment but also through the rearrangement of existing knowledge, the revision of previous knowledge structures, and the building and revision of theories. According to Dixon (1992), the organization acquires information both from external sources and by generating information internally (see Figure 2.4).

Creation of knowledge is the result of externalization and combination in the many internal processes. Categorizations were made by researchers such as von Hippel (1988) and Stinchcombe (1990) who found learning from customers and users particularly important to innovation. Dixon (1992) mentions that information can be generated internally by relying on prevailing technology and by understanding the history of the organization and the thoughts of the founders, by learning from experience and by experimenting - that is, developing original innovations, inventing new processes, and deliberately creating experiments, by implementing continuous process improvements and attending to feedback on incremental change, and thorough critical reflection, that is, questioning organizational assumptions and norms (see again Figure 2.4). Externally, the organization acquires

knowledge and information by borrowing from other organizations, by searching, by grafting and finally by collaborating with other organizations. Argote (1999, pp. 145-146) has more recently given examples of almost the same sources of knowledge acquisition as Dixon, which is interesting because Argote takes also the new web-technologies into account.

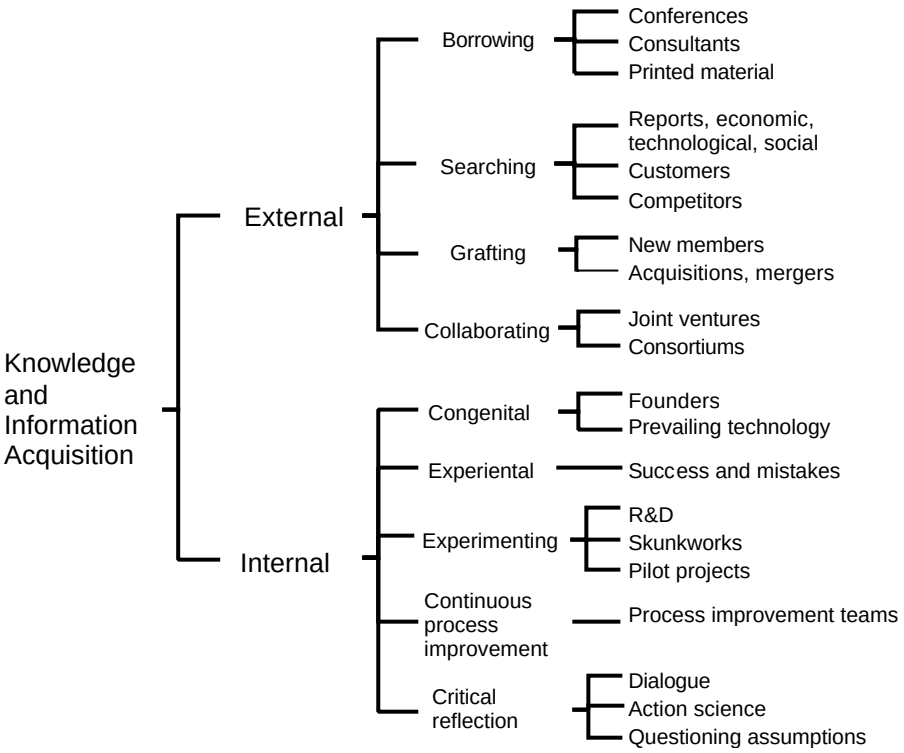

Figure 2.4 Knowledge and information acquisition (Dixon, 1992).

When discussing knowledge acquisition in the context of knowledge management it is common to talk about customer knowledge. Bierly and Hämäläinen (1995) have made an useful taxonomy, relating knowledge acquisition and learning to eight actor groups. Bierly and Hämäläinen argue that external learning takes place primarily thanks to boundary spanning individuals in the organization who exchange information and knowledge with the external environment. These boundary spanning individuals need to have a strong personal network of external as well as internal connections. Hansson (1988, pp. 88-89) calls such networks personal business networks and claims that their efficiency is a tool for acquiring knowledge as well as creating new business opportunities. Personal business networks are constructed through participation in courses and projects, as well as by spending time together socially. Bierly and Hämäläinen (1995) divide learning in external networks into learning from customers, from competitors, from the wide network, and from institutions (see Table 2.5).

Table 2.5 Domains of external and internal learning (Bierly and Hämäläinen, 1995)

Domain	Description / Source	Advantages	Impediments / Disadvantages
External			
Customer	Learning from end-user; market research; test marketing	Tap leading source of new ideas	Competitors usually have same access; customer may not know what it wants
Competitor	Licensing; joint ventures; R&D arrangements; R&D consortia; benchmarking	Learn highly relevant knowledge; can anticipate competitors' strategies	No competitive advantage; legal barriers (patents); competitor may be hard to imitate due to causal ambiguity
Network	Learning from firms in related and supporting industries; strategic alliances	Not direct competitors; more open knowledge exchange; reduced opportunism	May lack relevance; dependent on physical proximity
Institutional	Consultants; government regulations; personal relationships / networking	Learn industry norms; gain legitimacy	Typically does not lead to competitive advantage
Internal			
Individual	Development of new ideas via individual creativity	Development of most creative ideas	Organizational culture may discourage; individual may leave firm; new idea may not fit strategic goals
Interfunctional	Learning across functional areas; cross functional teams	Combine knowledge from different areas; increases causal ambiguity	Functional departmentalization; high specialization; lack of integrating mechanisms
Intrafunctional	Learning within workgroup	Knowledge stays within workgroup; knowledge can be highly specialized	Group dynamics; NIH-syndrome; different individual frameworks
Multilevel	Learning across vertical levels; top-down and bottom-up transfer of knowledge	Increases strategic focus of firm; facilitates strategic decision making and implementation	Bounded rationality; organizational politics

Internal learning improves the capabilities of the organization by increasing the shared knowledge of organizational members. Internal learning can according to Bierly and Hämäläinen be categorized into four domains: individual, intrafunctional (group), interfunctional and multilevel learning (organizational). As the characteristics such as the stability of industry environment or degree of specialization of an industry change, different domains of learning become crucial to the organization. Bierly and Hämäläinen further assert that an important task of strategic management is to facilitate knowledge acquisition by identifying and allocating resources to the crucial domains of organizational learning needed to develop a sustainable competitive advantage.

Information distribution

Information distribution refers to the processes by which an organization shares information among its units and members. Distribution of information is assumed by Dixon (1992) to be intentional and unintentional. Knowledge and information are distributed by oral and written communication, training, internal conferences, briefings, and internal publications. Brown and Duguid (1991) contend that a lot of learning and innovation takes place in informal communities of practice, where members of an occupational group or work team share their experience in an ongoing dialogue (Nevis et al., 1995). Very often, distribution in an organization takes place unintentionally when members share stories or anecdotes of actual work practice as opposed to

distribution with formal job descriptions or procedure manuals. Such communicative distribution also sustains informal networks. The famous water cooler (or Swedish coffee room) random discussion groups often become valuable sources of information (Davenport and Prusak, 1998, pp. 90-95). Huber (1991) suggests that wide distribution of information in an organization leads to more broadly based organizational learning. Nonaka and Takeuchi (1995, pp. 80-82) suggest that sharing of redundant information promotes sharing of tacit knowledge, because individuals can sense what others are trying to articulate. It can be argued whether job rotation, stories and taskforces are unintentional methods for distributing knowledge. The idea of both job rotation and telling stories is to distribute some kind of knowledge and when taskforces are formed for solving a particular task, it is well known that members learn from each other as all people do when they interact in social processes.

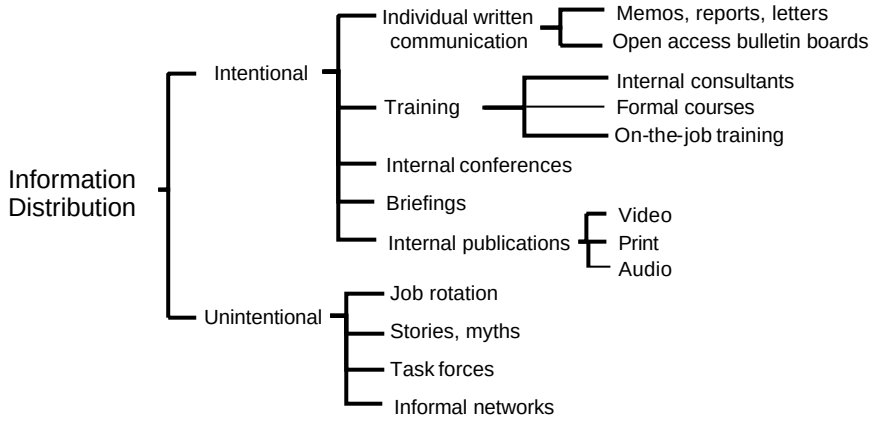

Figure 2.5 Information distribution (Dixon, 1992).

Daft and Huber (1987) suggest that the medium in which information and knowledge are distributed is important for reduction of equivocality. They say that unequivocal information can easily be distributed by letter, e-mail, or other written media and then be interpreted, while equivocal information may best be distributed by rich media such as face to face communication. Discussion and fast feedback act to construct shared mental models and reduce equivocality. The latter can be assumed to be explained by that it allows quick pendulum swings between distribution and making meaning of information.

Making meaning

Constructivism can be said to refer to a set of epistemological assumptions related to the principle that “reality exists but cannot be known” (von Glaserfeld, 1989). Knowledge about phenomena are attempts to make meaning of objects and events as they are perceived by individuals. Humans

are ultimately “meaning makers” who construct knowledge by forming connections between perceptions and those relevant aspects of prior knowledge stored in long-term memories (Ausubel, 1968). According to Daft and Huber (1987), there are two prevailing but complementing perspectives of organizational learning, the systems structural perspective and the interpretative perspective. The first perspective is concerned with amount, frequency, and distribution of information. It uses the tools of rational analysis and extrapolation from past events to give meaning to information. The second perspective, that of information interpretation, is the process by which distributed information is given one or more commonly understood meanings by exchange of views rather than the collection of additional data. By other words, interpretation can be seen as an account that renders a subject-matter intelligible.

According to Dixon, the systems structural and interpretative perspectives provide insight into how organizations assign meaning to information by analysing it. Information is put into a context where it can be understood and become knowledge. This is what occurs in the well known learning model presented by March and Olsen (1975) (already pointed to in section 2.4.2). Individuals try to modify their behaviour based on their learning from experience about their environment and then determine appropriate action. Methods included in the systems structural view of making meaning are rational analysis, problem solving processes, extrapolating from past events, strategy formulation, and use of decision support tools (see Figure 2.6, where Dixon’s terminology - Analyzing information - corresponds to the systems structural view). The use of more traditional information technology such as databases, search and retrieval tools can be extensive because information about past events can be stored in digital organizational memories.

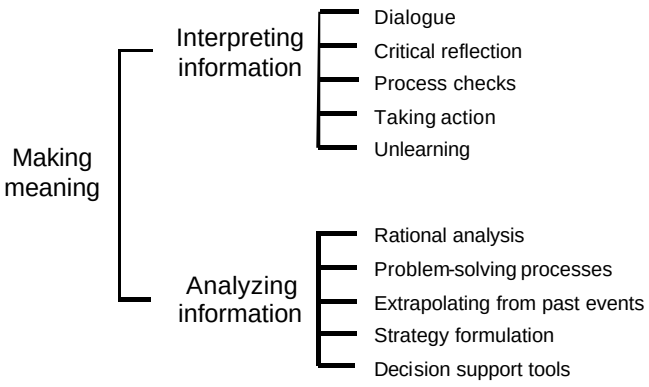

Figure 2.6 Making meaning (Dixon, 1992).

From the interpretative perspective the meaning of organizational information is invented rather than discovered by analysis. A consequence of invented

interpretations is that all individuals come to their own unique interpretations (Dixon, 1992). This results in multiple explanations of a given phenomenon within an organization. As we saw in section 2.4.1 and 2.4.2, Huber (1991) states that individuals and groups have prior belief structures (mental models) that shape their interpretation of information and thus their formation of meaning. These belief structures are stored as a rule-base or profile automatically applied to any incoming information to form meaningful knowledge that can be stored. The interaction between shared mental models and interpretation is critical to understanding how organizations learn. More learning occurs when more and more varied interpretations are developed. Organizational learning occurs when individual interpretations of a phenomenon is shared among many organizational members. Dialogue, critical reflection, process checks, common action, and unlearning are all actions that lead to that individuals share interpretations (Dixon, 1992 and Figure 2.6). For equivocal information the sharing of interpretation is critical, because such sharing reduces equivocality and leads to organizational learning, as proposed by Weick (1979) and later by Daft and Weick (1984) and Daft and Huber (1987).

Organizational memory

Organizational memory refers to the repository where knowledge is stored for future use (Walsh and Ungson, 1991)[13]. It is also called corporate knowledge and corporate genetics by Prahalad and Hamel (1994). Decision makers store and retrieve, according to Huber (1991), not only hard data or information but also soft information, that is, information with meaning. This soft or interpreted information may be in the form of tacit know-how, expertise, biases, experience, lists of contacts, anecdotes, etc. Organizational memory plays a crucial role in organizational learning. Both the demonstrability and usability of learning depend on the effectiveness of the memory of organizations. The major challenge for organizations is in making meaning of information and creating an easily accessible organizational memory.

Organizational memory can have different types of bearers or storage forms (Wikström and Normann, 1994, pp. 105-106). People are bearers of knowledge and are the only bearers who can communicate uncoded knowledge, i.e. tacit knowledge that is not manifest. People are, so far, the only bearers who can use their knowledge to create new knowledge[14].

[13] See also Stein (1995) for a review of organizational memory and Schein (1984) on collective memory.

[14] Machines are loaded with coded knowledge (explicit knowledge), which means that they can only carry out activities for which they are programmed. The development of artificial intelligence systems has not reached a point where it is meaningful to modify this basic assumption. Technical and administrative systems can be bearers of both coded and uncoded knowledge. Machines and people are combined in such systems to carry out particular processes such as project management. Documents are bearers of coded knowledge.

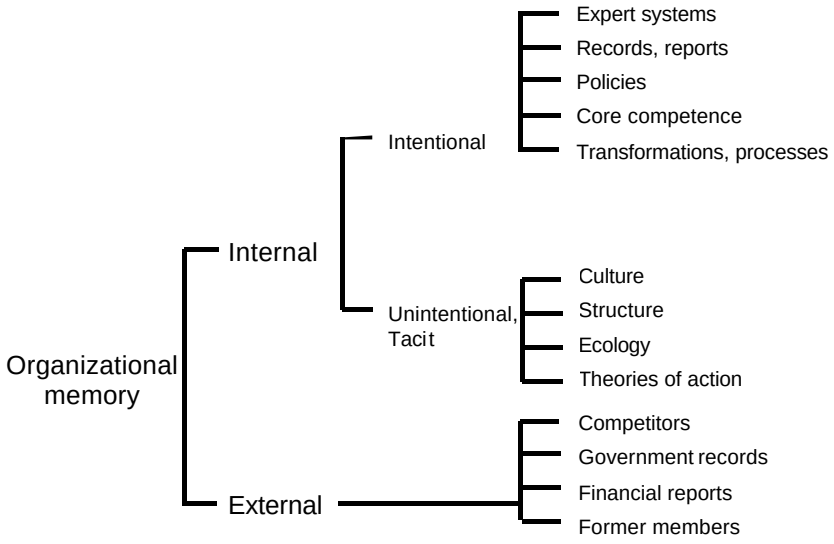

Figure 2.7 Organizational Memory (Dixon, 1992).

Dixon (1992), referring to Walsh and Ungson (1991), states that organizational memory can be stored internally or externally (see Figure 2.7). For internal knowledge, Dixon further uses the five "storage bins" (in which organizational memory resides) proposed by Walsh and Ungson (1991). Internal organizational memory can also be intentional or unintentional. Individuals retain unintentional knowledge based on their experiences and observations. Individuals also keep records and files as an intentional memory aid. These include expert systems, lessons learned, databases, records, and reports. Policies, core competence, and the transformations (that are the processes of the organization) of the organization also belong to the intentional internal memory (Dixon, 1992). The unintentional organizational memory consists of organizational culture[15] (including myths, stories, languages and symbols), roles that differentiate tasks and control (structures), the actual physical structure of the work environment and the physical workplace (ecology), and of theories of action. The latter includes two kinds of shared mental models, namely espoused theories and theories in use (Argyris, 1990). Theories-in-use as well as espoused theories are collectively held among members, but theories-in-use are held tacitly rather than explicitly, making them unavailable for examination and challenge.

Knowledge can also be stored in external archives. These external sources of knowledge are not parts of the organizational memory per se, but they do store information about the past of the organization, information that can be retrieved (Walsh and Ungson, 1991). Such sources are competitors, government records, financial reports, and former members of the

[15] See also Schein (1984; 1996a; 1996b) for a review of organizational culture.

organization (Walsh and Ungson, 1991), but also suppliers, customers and other business partners or project members can be mentioned.

Retrieval of information and knowledge

Retrieval of information and knowledge may, according to Dixon (1992), be either controlled or automatic (see Figure 2.8). Automatic retrieval of information and knowledge means that much of what is learned is so well learned and stored in the deeper structure of organizational memory that it is retrieved automatically. Most of the automatically retrieved knowledge is tacit. The retrieval of information and knowledge also differs depending on which "storage bin" it is stored in (Walsh and Ungson, 1991). Individuals in an organization retain knowledge based on their own direct experiences and observations, which can be automatically retrieved. At an organizational level, examples of automatic retrieval occur when present behaviours are based on previous practices that have been shared and encoded in transformations, organizational structures, culture, and workplace ecology (Walsh and Ungson, 1991)[16].

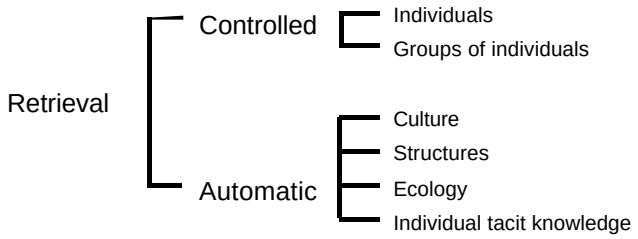

Figure 2.8 Retrieval of information (Dixon, 1992).

Individuals may retrieve information purposefully and consciously by making an analogy to past decisions. Groups of individuals can also cover the past as a collective and help each other to remember it. Technology support for controlled retrieval of at least computer-based parts of organizational memory is getting more advanced and easy to use. Various tools are being developed for intelligent just-in-time delivery of knowledge to the right receiver. Finally, when knowledge is retrieved and used, socialization among the users will start a new process of learning and knowledge creation (cf. Nonaka and Takeuchi, 1995, see section 2.5.5) where new knowledge can be acquired for future re-use.

[16] Transformations is the logic that guides the transformation of an input into an output. It may be practices from design work and standard operating procedures as discussed by Weick (1979). The organizational structure must, according to Walsh and Ungson, be considered in the light of its implications for individual role behaviour and its link with the environment. Roles provide a repository where knowledge can be stored.

A comparison of Dixon's and Nonaka's perspectives

A model of the continuous process of organizational learning and transfer of knowledge in organizations has been presented. It is based on a model proposed by Dixon (1992) and it consists of five sub-processes: acquisition, distribution, making meaning, organizational memory, and retrieval. From another perspective (Nonaka, 1994; Nonaka and Takeuchi, 1995), knowledge can be said to be created and transferred through the knowledge conversion process, which consists of socialization, externalization, combination, and internalization (cf. section 2.5). The perspective of Nonaka emphasizes the interplay between tacit and explicit knowledge while the perspective of Dixon emphasizes organizational learning and transfer of knowledge in a process oriented sense. Both perspectives share the assumption that communication and learning are necessary for knowledge to be transferred. Furthermore, both perspectives are based on the assumption that providing conditions such as a process perspective on managing knowledge and a knowledge friendly environment enables the organization to learn and transfer knowledge. The next section turns to the conditions for learning and knowledge transfer.

2.7 Enablers and facilitators for learning and knowledge transfer

Writers on knowledge management approach the issues of learning and knowledge transfer while using concepts that express enabling or facilitating factors. Thus Nonaka and Takeuchi (1995) use "enabling conditions for organizational knowledge creation" while Davenport and Prusak (1998) use "conditions contributing to organizational effectiveness by enabling knowledge projects". Previously in the area of organizational learning Fiol and Lyles (1985) presented four "contextual factors that affected the probability that learning will occur". Daft and Huber (1987) presented three "conditions for learning" that added technology to the list of previously presented conditions. Similarly Senge (1990) presented five "disciplines that enable organizational learning". Argote (1993) added further "necessary conditions" to the list of organizational learning and later Ayas (1996) and Bartezzaghi et al. (1997) presented "special conditions that enabled interproject learning". More recently Skyrme and Amidon (1997) and O'Dell and Grayson (1998) proposed "key enablers for knowledge management efforts" respectively "enablers of knowledge transfer". Instead of conditions some authors used terms such as action or activities that facilitate organizational learning (Hedberg, 1981) and where Nevis et al. (1995) later added "facilitate the transfer of knowledge" after organizational learning. Finally Garvin (1993) proposed five "activities helping organizations to learn". Table 2.6 includes frequently cited writers in knowledge management and in organizational learning.

In this table, an attempt has been made to classify the emphasis of various authors as either enabling condition (E) or facilitating activity (F). On the one hand, enabling conditions or enablers are characterized as sets of contextual factors and conditions that provide a proper context for organizational learning (Fiol and Lyles, 1985; Daft and Huber, 1987; and Argote 1993) or knowledge creation and transfer (Nonaka, 1995; Nonaka and Takeuchi, 1995, pp. 73-83; Ayas, 1997; Bartezzaghi et al., 1997; Skyrme and Amidon, 1997; Davenport and Prusak, 1998; and O'Dell and Grayson, 1998). On the other hand, following Hedberg (1981), Senge (1990), Garvin (1993) and Nevis et al. (1995) the use of actions or activities, many times to fulfil enabling conditions, are identified here as facilitating activities or facilitators.

Table 2.6 Enabling conditions (E) and facilitating activities (F) for learning and knowledge management.

Author	Emphasis	Enabling conditions or facilitating activities
Argote (1993)	Necessary conditions for organizational learning (E)	Increased proficiency of individual workers, Improvements in the organization's structure, organization and methods of coordination, Better understanding of who in the organization is good at what, Improvements in the organization's technology, tooling, and layout
Ayas (1997)	Inter project learning (E)	Leadership, Teambuilding, Co-location (networking), Human resource management, Management support
Baartezzaghi et al. (1997)	Inter project learning (E)	Managing project feedback, Use vehicles for embodying and disseminating improvements, Adopt project classification schemes (to improve identification)
Daft, Huber (1987)	Organizational learning (E)	Organization structure, Communication strategy, Technology
Davenport, Prusak (1998)	Knowledge management project success (E)	Knowledge oriented culture, Technical and organizational infrastructure, Senior management support, A link to economics or industry value, A modicum of process orientation, Clarity of vision and language, Nontrivial motivational aids, Some level of knowledge structure, Multiple channels for knowledge transfer
Fiol, Lyles (1985)	Organizational learning (E)	Culture, Strategy, Structure, Environments
Garvin (1993)	Organizational learning (F)	Systematic problem solving, Experimentation, Learning from own experience and history, Learning from the experiences and best practices of others, Transferring knowledge
Hedberg (1981)	Organizational learning (F)	Learning about organizational learning, Promoting experimentation, Regulating awareness by exposure to external variation, Redesigning environments, Achieving dynamic balances
Nevis, DiBella, Gould (1995)	Organizational learning (F)	Scanning imperative, Performance gap, Concern for measurement, Experimental mindset, Climate of openness, Continuous education, Operational variety, Multiple advocates, Involved leadership, Systems perspective
Nonaka, Takeuchi (1995)	Knowledge creation (E)	Organizational intention, Autonomy, Fluctuation and creative chaos, Redundancy, Requisite variety
O'Dell, Grayson (1998)	Knowledge management (E)	Culture, Technology, Infrastructure, Measurement
Senge (1990)	Organizational learning (F)	Five disciplines: Systems thinking, Personal mastery, Mental models, Shared vision, Team learning
Skyrme, Amidon (1997)	Knowledge management (E)	Strong link to business imperative, A compelling vision and architecture, Knowledge leadership, A knowledge creating and sharing culture, Continuous learning, A well developed technology infrastructure, Systemic organizational knowledge process

Analysing the enabling conditions (E) in Table 2.6 there seems to be five types: (1) leadership and management support, (2) organizational intention with connections to strategy and operational measurements, (3) clarity and structure of knowledge, (4) technology and infrastructure, and finally (5) a knowledge oriented culture. Among the facilitators (F), there seems to be a consensus implying that there are three types: (a) creating shared mental models and a knowledge friendly culture which promotes experimenting, etc.

(b) creating knowledge repositories for experience and history, and (c) applying systems thinking to facilitate organizational learning first and foremost but also knowledge management. For the purpose of the present investigation, six types of enabling conditions have been chosen: (1) *Organizational structure*, (2) *Communication and the monitoring of strategy*, (3) *Process*, (4) *Culture*, (5) *Systems for training and learning* and finally (6) *Technology*. Each of these enabling conditions is associated with a particular type of facilitating activities except the sixth enabler (Technology).

As appears from section 1.5.2 and section 2.3.6, most of what can be learned about enablers for organizational learning can be referred to two main categories: (1) managing and organizing the business and (2) technology or technological infrastructure. Davenport and Prusak (1998, p. 155) as well as Zack (1999) assert that knowledge management efforts are more likely to deliver a positive result if they can take advantage of a broader infrastructure of both the organization and the technology. Building an organizational infrastructure for knowledge management means establishing an organizational structure, a set of roles, a knowledge strategy, a knowledge oriented culture, and feedback mechanisms from which the organization can benefit. Building a technological infrastructure is to establish technical process support and skills to use such support. According to Davenport and Prusak (1998, p. 155), however, the technological infrastructure seems to be the easier of the two to put in place. The following two sections discusses enabling conditions and facilitating activities from the organizational perspective as well as enabling conditions from the technological perspective.

2.7.1 Organizational enablers and facilitators for learning and knowledge transfer

In this section, the first five enablers just identified are used to structure an overview of the relevant literature.

Organizational structure

According to Daft and Huber (1987) organizations need two systems in order to transfer knowledge and learn through communication. First a logistical system to process data and information and then an interpretative system to enable the appropriate perception of data and information and turning it into knowledge. The organizational structure, the communication strategy, and technology are necessary conditions in such systems. They also assert that an organization can be structured to reduce equivocality seen through the lens of the interpretative perspective or to promote internal communication and information transfer seen through the lens of the systems structural perspective. Internal communication is promoted by adding organizational

positions that process information, and placing organizational members in direct contact reduces equivocality. Similarly, Fiol and Lyles (1985) propose organizational structure as one of four contextual factors affecting the probability for learning to occur. According to them, structure plays a crucial role in determining the outcome of learning because some kinds of structure such as centralized, mechanistic structures tend to reinforce past behaviours, unlike organic structures. Organizations purposefully adopt structures as well as strategies to encourage learning. Organizations are not totally reactive, and can proactively seek to influence the environment in which they learn. Each individual has his or her own knowledge base and learning capabilities, just as each department in the organization. The structure of the organization defines the way in which these processes interact, and gives rise to the organizational learning process resulting from these interactions (Dodgson, 1994, p. 387). To summarize: structure determines who is going to cooperate, meet and share tasks as well as knowledge.

Improving knowledge access, as discussed by Davenport et al. (1998), has implications for organizational structure as well as technological structure. The organizational structure can, for example, support knowledge maps, expert networks, job rotation, task groups and teamwork. Katzenberg and Smith (1993) have demonstrated that teamwork can be one of the best ways to integrate across boundaries. As learning and knowledge transfer need to be coordinated and as real teams are self-managing, a team structure seems to be well suited for learning as well as transfer of knowledge.

As an application of Katzenberg and Smith's (1993) theory of teams, Ayas (1997) suggests that large projects should be organized in many self-managing teams (SMT) that are integrated into a project network structure (PNS). The SMTs spring from a core team where the members are team leaders. If necessary, the SMTs can also become a sub-core-team and develop its own SMTs. This kind of network organization should provide a base for effective transfer of knowledge and increased learning capacity. As much knowledge in an organization is tacit and stored in the heads of its members, the knowledge transfer system has to facilitate dialogue and externalization, as well as combination and socialization. Some critical factors mentioned by Ayas are: leadership (team-leaders aware of team development); teambuilding (determines the effectiveness of SMTs in projects); co-location (at least networking through e.g. computerized networks); human resource management (such as training, job-rotation, and rewards); and management support (top down pressure to support the bottom-up pressure from the network.) What Ayas says about organizing single projects might work for organizations in multi-project environments as well. Each project can be managed by an SMT in the same way as a sub-project in the large project. This enhances organizational learning. Nonaka (1994) also emphasizes the use

of SMT as a trigger (facilitator) for learning, as it facilitates mutual trust between team-members and also communication by dialogue.

Communication and the monitoring of strategy

Communication and the monitoring of strategy also enable and facilitate learning and knowledge transfer. Nevis et al. (1995) have designated ten factors that facilitate learning, two of which are relevant from an organizational structure perspective. Structures and processes affect how easy or difficult it is for learning to occur. In their model, ten factors enable seven learning orientations that reflect where in the transfer process learning takes place and the nature of what is learned. Nevis et al. (1995) claim that their first facilitating factor - Involved leadership - is the most important for communicating and monitoring a strategy. Davenport and Prusak (1998) emphasize management support for knowledge management as for almost every other type of change program. Good leaders articulate visions, are engaged in their implementation, interact frequently with members, and become actively involved in educational programs (Nevis et al., 1995). Good senior management also send messages that organizational learning and knowledge management are critical, clarify what types of knowledge are most important, and provide funding and other resources for them (Davenport et al., 1998; Davenport and Prusak, 1998). Therefore, Nevis et al. (1995) further assert the importance of multiple advocates for knowledge related issues, this being their second factor. The more advocates who promote a new idea, the more rapidly and extensively the learning will take place. Employees at all levels will advance new ideas and methods.

It is often claimed that no matter how many advocates support something, little will happen if there are no strategies and guidelines. Nonaka and Takeuchi (1995, pp. 74-83) emphasize enablers at the organizational level that provide a proper context for group activities as well as creation and accumulation of knowledge at the individual level. The first of their five enablers that promote the knowledge spiral (see section 2.5.5) is organizational intention. It is defined as the organization's aspiration to reach its goals, and it springs from the corporate strategy in which the critical element is to create a vision about what kind of knowledge should be developed and operationalized into a management system. The authors conclude by asserting that it is not possible to understand the meaning of information about the environment without intention that is communicated throughout the organization (Nonaka and Takeuchi, 1995, pp. 74-75).

Fiol and Lyles (1985) proposed strategy as their second contextual factor of four. Strategy partially determines the learning capacity by determining the goals and objectives and the breadth of actions available for carrying out the

strategy. Strategy provides a context for the perception and interpretation of the environment and therefore affects knowledge creation and transfer. If either external or internal environments are too complex or dynamic to handle, information overload may occur, and learning will not take place (Fiol and Lyles, 1985). A special case of strategy, but important for learning and transfer of knowledge, is a communication strategy (Daft and Huber, 1987). They assert that a communication strategy is to encourage people to meet face to face to interpret and make meaning of equivocalities and transfer non-routine information. The communication strategy is used to communicate the organizational approach to acquiring and handling data (Daft and Huber, 1987). On the one hand, using the systems structural perspective, the aim is to set priorities and decide what type of information is important. On the other hand, using the interpretative perspective, the aim is to give guidelines such as encouraging face-to-face meetings and discussions, and to encourage rapid cycles among managers, as well as to set few rules.

Clarity of vision and language is said to be a consequence of a well-communicated strategy (Davenport and Prusak, 1998, p. 158). Strategy, goals and concepts associated with knowledge creation and transfer must be clear to everyone in the organization. Skyrme and Amidon (1997) assert that a compelling vision and conceptual architecture build a common language and define key domains for knowledge. Such domains create knowledge structures, often based on the individual pattern of use of concepts (Davenport and Prusak, 1998, p. 159). One application of this, the project classification schemes proposed by Bartezzaghi et al. (1997), consists of several dimensions according to which the project may be identified (e.g. size, type of relationships with client and suppliers, major technologies involved). Each dimension is divided into subclasses that may improve the organizational abilities to identify similarities and to exploit inter-project learning.

Parallel to clarity of vision and language there has to be a link from knowledge to economics or industry value (Davenport and Prusak, 1998) or to business imperatives (Skyrme and Amidon, 1997) in order to realize the organizational intentions. Nevis et al. (1995) as well as O'Dell and Grayson (1998, pp. 126-138) note the importance of measurement as a support for learning. Organizations strive for specific and quantifiable measurement (Nevis et al., 1995). It is well known that measurement tends to have effects on both individual and organizational behaviour. Measurements are therefore necessary to monitor the strategy and to enable learning and knowledge transfer. Measurement also allows feedback and learning by measuring performance gaps, as stressed by Nevis et al. (1995).

A second effect of measurement is its impact on motivation. O'Dell and Grayson (1998, p. 137) stress that without measurements, enthusiasm from employees and management will disappear. However, motivational aids or incentives for knowledge creation and transfer should not be trivial (Davenport et al., 1998; Davenport and Prusak, 1998, p. 158). They should be long term incentives tied in with the rest of the evaluation and compensation structure (Davenport and Prusak, 1998, p. 158). Career development, training, promoting internally, rewarding top performers, and making sure that the employees are satisfied with their work are ways to inspire an organizational culture that recognizes the importance of people (O'Dell and Grayson, 1998, p. 74). Rewards leading to such a culture will also make it easier for the organization to attract good people in the market for professional labour (Maister, 1993).

Process

Measurements, knowledge structures and classification schemes allow organizations to manage knowledge as a process. According to Skyrme and Amidon (1997) such enablers help the organization to build a framework for identifying, capturing and diffusing (cf. the typology by Dixon in section 2.6.2) knowledge in a structured way. Davenport and Prusak (1998, p. 157) assume that knowledge management can be seen as a process but that project managers in their study did not find it useful to describe such processes, seeing knowledge management instead as integrated in other daily operations and processes. Garvin (1993) took quite a rational, normative approach to building learning organizations. Based on empirical studies of organizations known for good learners, he proposed that learning organizations are skilled at five main activities, two of which are interesting from a process perspective. Organizations known as good learners focus on learning from past experience and learning from own experience and best practice of others, which can be seen as an application of knowledge acquisition from internal as well as external sources and retrieval as described by Dixon (1992).

Aquisition and learning from external sources can, however, be facilitated by regulating awareness of exposure to external variation (Hedberg, 1981) by the use or non-use of perceptual filters. Exposure to a wide variety of stimuli keeps learning systems alert. Nevis et al. (1995) answers to this by introducing the scanning imperative. They give an empirical example in which Motorola gathered information about conditions and practices outside the firm to provide awareness of environment. On the other hand, Nonaka and Takeuchi (1995, pp. 78-80) assert that fluctuation and creative chaos stimulate interaction between the organization and the external environment. Fluctuation differs from complete disorder and is characterized by "order without recursiveness". When fluctuation is introduced in the organization, its

members face a “breakdown” of routines, habits and cognitive frameworks. The breakdown provides an opportunity for people to reconsider their fundamental thinking and perspective. A breakdown demands social interaction and dialogue that helps to create new concepts. Chaos is generated naturally when the organization faces real crises or when management intentionally creates a crisis e.g. by proposing challenging goals. Nevis et al. also propose that intentional crises, creating chaos, increase tension within the organization and focus the attention of organizational members on defining and solving the problem. Equivocality can act as a trigger for individual members to change their fundamental ways of thinking (Daft and Huber, 1984) and to externalize tacit knowledge. However, as Nonaka and Takeuchi warn, creative chaos can easily be turned into destructive chaos if the members do not have the ability to reflect upon their actions.

External and internal knowledge are both assumed to be stored in organizational memory, once it has been acquired, distributed and given a meaning (Dixon, 1992). Davenport et al. (1998) claim that knowledge repositories (or memories as Dixon calls them) can be intentionally created to store knowledge, and also provide for easy retrieval. What Bartezzaghi et al. (1997) propose is deliberate use of vehicles for embodying and disseminating improvements. Transfer of knowledge and of lessons learned to future projects is complex and neither natural nor spontaneous. To make knowledge available in any part of the organization in future periods, learning can be embodied in vehicles. Several kinds of vehicles are discussed to serve this purpose: people, reports and databases, organizational elements (such as procedures, tools/methods, processes, structures, and principles) and technological elements (such as CAD-libraries, design rules, standard formulae, standard solutions, and product platforms). Similarly Argote (1999, p. 145) assumes that knowledge can, in general terms, be transferred by moving people, technology, or structure to the recipient organization or by modifying people, primarily through training, and by modifying technology and structure of the recipient organization. What Bartezzaghi et al. (1997) call vehicles are the same as what Huber (1991) and later Dixon (1992) call storages in the organizational memory. They all think that by using selected vehicles, it is possible to facilitate transfer of specified knowledge. Searchable memory systems and knowledge maps can also improve access to knowledge and facilitate its transfer.

Nonaka and Takeuchi (1995, pp. 82-83) propose requisite variety as an enabler for knowledge creation. Efficiency must be maximized by the organization by matching the internal diversity of the organization with the variety and complexity of the environment. As redundancy increases the amount of information to be processed (and thereby the cost of knowledge creation and transfer) they assume that it is important to find a balance

between creation and information processing. One way of dealing with this issue is to make certain the location of information and knowledge storage in the organization. Efficient knowledge creation and transfer requires quick inquiry and pre-processing of existing knowledge and information. It is therefore practical for everyone to be given access to necessary information with the minimum number of steps. Another possibility is to react quickly to fluctuations in the environment and maintain internal diversity by changing the organizational structure frequently. Senge (1990) challenges prevailing structures, using his five disciplines to describe how to enable organizational learning. He stresses the importance of (1) bringing prevailing mental models to the surface and challenging them and (2) building a renewed shared vision. Such challenges are close to what Hedberg (1981) called unlearning and that is a process through which learners discard knowledge and makes way for new responses and mental models.

Given the circumstances in which organizational memories exist, there seems to be a need for a systematic approach. The fifth discipline proposed by Senge, systems thinking, is what he calls the most important discipline, because it is said to integrate the other disciplines and fuse them into a coherent if static body of theory and practice. The five disciplines have more recently been criticized by Rifkin and Fulop (1997) as contradictory. However, a systems perspective is also proposed as an enabler for organizational learning by Nevis et al. (1995). They ask whether managers think broadly about the interdependence of organizational units and variables before taking decisions. Problems and solutions can be seen in terms of systemic relationships among processes where the connection between the needs and goals of the unit or the firm must be considered. Similarly, Garvin (1993) promotes a positivistic and systematic problem solving perspective in order to facilitate organizational learning. Scientific methods, insisting on data rather than assumptions, and the use of statistical tools are what he recommends.

Culture

Much creation and transfer of knowledge can be enabled by a knowledge oriented culture. Davenport and Prusak (1998) found knowledge-friendly culture to be one of the most important enabling conditions. Similarly, culture was one of the four contextual factors that affected the probability for learning to occur in the study of Fiol and Lyles (1985). Skyrme and Amidon (1997) and O'Dell and Grayson (1998) all stress organizational culture as an enabling necessary condition for knowledge transfer.

Organizations can remove formal barriers to create a knowledge oriented culture (Fiol and Lyles, 1985; Skyrme and Amidon, 1997; Davenport and Prusak, 1998; O'Dell and Grayson, 1998). It can then be assumed that various

organizational arrangements can change the organizational culture. Instead of culture, Hedberg (1981) focused on redesigning internal and external environments. He suggested a redesigned internal environment with conditions encouraging risk-taking and experimenting, which would enable learning. Fiol and Lyles (1985) also proposed an environment with a balance between stability and change, as both are needed for learning. Change should thereby be a more or less permanent stage in an organization. Davenport et al. (1998) highlight another aspect of the knowledge environment, which is to build awareness and cultural receptivity to knowledge and the process of managing it.

As a part of the organizational culture Nevis et al. (1995) propose to create a climate of openness as a facilitating activity. This means great accessibility of information and open communication within the organization. Obviously, there is a connection to communication strategy, but technology can be an enabler for an organization to attain an open climate through providing multiple channels for knowledge transfer and increasing access to knowledge. Problems, errors, or lessons are shared, not hidden. Debate and conflict are acceptable ways of solving problems. Nevis et al. (1995) also propose an experimental mindset. This includes support for trying new things, and it encourages curiosity of how things work. Organizational members develop an ability to play with things and to accept, not punish failure. Changes in work processes, policies, and structures are seen as a continuous series of learning opportunities.

According to Nonaka and Takeuchi (1995, pp. 75-78), autonomy also enables a knowledge oriented culture. This means that all members of an organization should have the possibility to act as autonomously as the circumstances permit. The organization might then increase its chance of introducing unexpected opportunities. Autonomy also increases the possibility that individuals will be motivated to create new knowledge. To achieve autonomy, Coleman (1999) adds that people must get the opportunity to interact with others in a non-purposeful way. Examples of organizational arrangements that spring from such cultures are informal networks (Davenport and Prusak, 1998, p. 37) and communities-of-practice (Brown and Duguid, 1991). In a more recent text, Brown and Duguid (2000, p. 94) advocate lateral ties as channels for knowledge transfer, refusing to see them as non value adding, as they are generally considered. Where knowledge can flow, learning can take place and the organization should get the opportunity to build an organizational memory, create knowledge maps and identify best practices.

Davenport and Prusak (1998) assert that what is often seen as the most successful knowledge transfer within an organization has nothing to do with technology or formal reporting structures, but with informal social groups.

Random discussion groups (meeting at the water cooler, coffee room, talk room, knowledge fair, open forum or organizational library) often become valuable sources of information (Davenport and Prusak, 1998, pp. 90-95). Open fora serve as hosts for conversations which, according to Webber (1993), are the most useful form of work in order to create and transfer knowledge. Many firms today have instituted formal social activities outside of the normal workday, activities that not only build employee morale but also develop stronger knowledge links throughout the organization.

Organizational arrangements to promote a knowledge oriented culture are sometimes difficult to design and implement. It must, however, be concluded that organizations should support informal as well as formal communication and collaboration in order to create and transfer knowledge.

Systems for training and learning

One type of enablers and facilitators is related to the importance of feedback and continuous learning. The literature shows two entrances to what Skyrme and Amidon (1997) call continuous learning: one entrance via project feedback (Bartezzaghi et al., 1997) and performance gaps (Nevis et al., 1995), and another via human resource management (Ayas, 1997) and training (Nevis et al., 1995; Senge, 1990).

As mentioned above, Nevis et al. (1995) discuss the importance of measurement and of measuring performance gaps. Gaps lead the organization to recognize that learning needs to occur or that something already known may not be working. Performance shortfall can then be seen as an opportunity for learning. Bartezzaghi et al. (1997) propose managing project feedback as an enabling condition for the application of inter-project learning in new product development projects. They state that it is especially during the design-review activities in projects that data are gathered and variances with initial plans are analysed. These variances can be collected as a basis for improvements in the specific project output and also used to improve the general design process. They also mention that variances may be analysed in audits and at the end of the project.

The interest in human resource management (HRM) expressed by Ayas (1997), especially training, represents the second approach to continuous learning. As an application of this Nevis et al. (1995) propose continuous education and lifelong training at all levels of the organization. Senge (1990, pp. 5-12) recognizes that many organizations suffer from learning disabilities and he proposes the learning organization as a solution. He suggests that managers adopt his five disciplines, of which two are relevant in this section. He encourages organizations first, on the individual level, to enable their staff to develop personal mastery (openness and trust) and second, to facilitate

team learning on the group level. Personal mastery should come from continuous education and similar efforts, which was later proposed by Nevis et al. (1995) as facilitator for organizational learning.

Team learning springs from team building as proposed by Ayas (1997) but according to Ayas this depends on co-location (networking) of individuals or on other conditions dictated by organizational structure (Daft and Huber, 1987; Fiol and Lyles, 1985). Hedberg (1981) went a step further and proposed learning about organizational learning as a facilitating activity for creating continuous learning. Continuous learning was later proposed by Skyrme and Amidon (1997) as an enabler for knowledge management. From the discussion above it seems that contributions from both the entrances to learning are necessary and it can be seen that they are also complementary.

2.7.2 Technological enablers for learning and knowledge transfer

A number of facilitating activities related to technology have now been mentioned. The focus will now be on the technology itself as an enabling condition for learning and knowledge transfer. By technology[17] is meant information technology, including telecommunications, in the present discussion of enablers.

Daft and Huber (1987) asserted that technology gives organizations multiple high speed channels for communication. Some technologies allow people to see one another and transfer rich information, which reduces equivocality and creates jointly constructed interpretations and meaning among individuals. Technological development contributes to the large number of knowledge process tools available. Different tools contribute more or less to different stages in the knowledge transfer process and also to transfer various types of knowledge. Therefore, Coleman (1999) assumes that to understand the knowledge transfer process and to guide resources to the right place at the right time are necessary before entering the tool selection.

It is generally acknowledged that there is a need to create multiple channels for knowledge transfer (Davenport and Prusak, 1998). Nevis et al. (1995) discuss operational variety for increased transfer: a variety of methods, procedures, and systems. Following Nonaka and Takeuchi (1995, pp. 80-82) redundancy, or intentionally overlapping information about business activities,

[17] The knowledge transfer process proposed by O'Dell and Grayson (1998) is supported by two technology related enablers: technology and infrastructure. They make a distinction between technology and infrastructure. Technology is limited to technological support tools in the shape of various software applications. They define infrastructure as hardware, work-processes and networks of people, put in place to ensure transfer. However, just as it can be difficult to categorize into hardware and software, it seems to be pointless to distinguish technology from infrastructure in the descriptions given by technical consultancy organizations. To simplify the terminology, the term technology is used here also for what they call infrastructure.

management responsibility and the firm as a whole, promotes sharing of tacit knowledge because individuals can sense what others are trying to articulate. The authors use the term overlapping information to mean information that goes beyond the immediate operational informational requirements discussed by Galbraith (1973). Redundancy helps the organization to build unusual communication channels and helps the individuals to understand where they stand in the organization. Strategic rotation of personnel, also discussed by Nonaka and Takeuchi (1995), is said to increase variety and to help the individual to understand the business from different perspectives.

Information technology supports the knowledge processes to a much greater extent than previously. However, it should not be forgotten that information technology can only act as a channel and storage system for knowledge transfer (Davenport and Prusak, 1998, p. 18). When it comes to capability, Armistead (1999) assert that there are four types of technology to be considered: (1) databases, (2) decision support tools and artificial intelligence, (3) groupware including e-mail and video conferencing, and (4) web technology providing us with intranets, extranets and the Internet. Higher capability and dispersion of technology have increased the opportunities for collaborative working with participants who are separate in both time and space.

Media richness is essential for this kind of development. Daft and Lengel (1984) listed various media for communication and found face to face consultation the richest medium, followed by group meetings (including video conferences), telephone, written personal (such as facsimile, e-mail, hand written notes, letters), written formal (such as reports), and numeric formal. Voice mail, bulletin board systems and newsgroups can be localized somewhere between telephone and written personal. These early observations are also verified to a large extent by Zmud et al. (1990). However, Carlson and Zmud (1999) have recently shown in an empirical study that communication effectiveness and richness perceptions are strongly bounded by the channel user's communication experience.

A rich mix of information can nowadays be transferred through multimedia channels supported by web technology. It can therefore be said that some media are more or less than others suitable for transferring or making knowledge available with a higher content of tacitness. Armistead (1999) guesses that the increased richness of multimedia approaches will offer a greater opportunity to explore tacit knowledge in general. Web technology will further help to create knowledge maps, identify knowledge that is nontrivial and time-consuming to describe, and ultimately make it available to others.

Much of the technology support available for knowledge management has existed within organizations for a long time. Examples of such support are

facsimiles, copiers, telephones and computers. More recently networks, desktop and laptop computers, databases and mobile technologies have made their entry in technical consultancy organizations. It is a common theme in literature to discuss a range of technological tools that support business processes. In recent years many of those tools have been combined and integrated into what is known as knowledge management architecture (Borghoff and Pareschi, 1998, p. 4). Borghoff and Pareschi (1998, p. 5) exemplify with an architecture that consists of four components:

1. *The flow of knowledge*: using knowledge, competencies, and interest maps to distribute documents to people.
2. *Knowledge cartography*: knowledge navigation (tools to map communities of practice), mapping (maps of people's competencies and interest, domain specific concept maps) and simulation (work process simulation).
3. *Communities of knowledge workers*: consisting of experience capture, contexts capture, awareness services and shared workspace.
4. *Knowledge repositories and libraries*: search opportunities, document repositories, directories, links, publishing and documentation support.

According to Borghoff and Pareschi, this architecture can be seen as a theoretical extension covering IT support to the knowledge conversion process proposed by Nonaka and Takeuchi (1995). It is also validated by internal experience, case studies and interviews in the Xerox Corporation (Borghoff and Pareschi, 1998, p. 6). Tiwana (2000, pp. 121-122) presents another similar architecture. His five components of architecture differ principally in that the last component covers advanced software support:

1. *Knowledge flow*: components that enable knowledge flow within the knowledge management system.
2. *Information mapping*: links and maps the flow of information that might later be converted to knowledge.
3. *Information sources*: consisting of data sources that feed raw data and information into the knowledge management system (cf. knowledge acquisition in section 2.6.2).
4. *Information and knowledge transfer*: refers to tools and non technological enablers that enable transfer of information across tacit (such as between people) and explicit (such as between databases) boundaries and help to share and create context and facilitate information interpretation (see again section 2.6.2).
5. *Intelligent agents and network mining*: refers to knowledge mining, linking, retrieval, and intelligence tools that make it possible to find knowledge using intelligent agents and pattern mining.

However, there are ambiguities in both the models and various components tend to overlap. It is not clear from the model proposed by Borghoff and Pareschi what belongs to the flow of knowledge and to communities of knowledge workers respectively. Is not the reason for the existence of communities that they enable knowledge flows? Similarly the architecture proposed by Tiwana (2000) is ambiguous when it comes to separating knowledge flow from information and knowledge transfer. In the present investigation, there is a need for an architecture that can more easily be combined with Dixon's (1992) process of knowledge and information transfer and with the technological support tools used by technical consultants. A new model inspired by Tiwana will therefore be used in this investigation, much because he ties most of the modern technological support tools to his model. Like the model proposed by Borghoff and Pareschi, the new model should accommodate also the knowledge conversion process proposed by Nonaka and Takeuchi (1995). The model chosen for the present investigation consists of four categories of technological enablers: *knowledge transfer tools*; *knowledge mapping tools*; *memory tools*; and *knowledge combination tools*. Each category of technological enabler contributes something to the various sub-processes in the knowledge transfer process and to the various modes in the knowledge conversion process as well (see Table 2.7).

Table 2.7 Four categories of technological enablers and their main contributions to the knowledge transfer process and the knowledge conversion process.

Enablers	Knowledge transfer sub-processes					Tacit (t) – Explicit (e)	Knowledge conversion modes
Knowledge transfer tools	A	D	M		R	t-e-t	S, E, C, I
Knowledge mapping tools	A			O	R	t-e	E
Memory tools				O	R	e	E, C
Knowledge combination tools	A		M		R	e-e	C

The knowledge transfer process: A (Knowledge acquisition), D (Information distribution), M (Making meaning), O (Organizational memory), and R (Retrieval of information). Modes in the knowledge conversion process: S (Socialization), E (Externalization), C (Combination), and I (Internalization).

Knowledge transfer tools

The first technological enabler, the knowledge transfer tool category, contains tools that enable the knowledge of an organization to flow. Knowledge and information flows are necessary for knowledge conversion as well as learning. Examples of tools and enablers for transfer of explicit knowledge are collaborative annotation tools, messaging integration, viewing tools, legacy integration, conversation threading mechanisms, and information beading tools. When enabling transfer close to the tacit end of the knowledge spectrum, Tiwana (2000) mentions tools such as context addition mechanisms, rich-media Internet conferencing systems, video conferencing tools, water coolers (virtual as well), community building networks, the telephone, mind maps, visual thinking software, and whiteboards (including digital).

To transfer knowledge there must be collaboration (Wathne et al., 1996, pp. 56-66) for distributing, interpreting and making meaning of information (Dixon, 1992). Brainstorming sessions, problem solving, idea generation and strategy planning meetings are examples of collaborative knowledge-based activities related to innovation and responsiveness. Such activities usually involve many people from different locations, departments and functions. The basic technological tool to support collaboration in such situations is groupware (Tiwana, 2000, p. 124). Groupware provides collaboration, document exchange and repository. Some widely used groupware tools are Lotus Notes, Netscape Collabra, Net meeting tools and e-mail tools. In an article from 1999, Coleman developed and described a groupware taxonomy with twelve categories. All these collaborative tools help to externalize tacit knowledge into explicit knowledge that is easier than tacit knowledge to store as structural capital and to transfer.

Transparent capture enablers are tools that can capture informal notes and sketches either by scanning from paper or providing an original digital environment (e.g. Crosspads). Even discarded ideas can thereby be captured for later use in other projects. Mind mapping is a visual method that can be used to organize individual or collective thought in visual presentations. Some software tools also allow for real-time collaboration and collective deliberation over the Internet (Tiwana, 2000, p. 137).

Intranets and extranets help people to find (acquire), give access to (publish), and distribute information and knowledge. Intranet solutions allow firms to create internal networks with access to many databases across the firm and over the Internet. Extranets go one step further in providing partners, clients and suppliers with access to restricted parts of the intranet, as customized for each actor. Intranets and extranets provide opportunities for cooperation as well as low search costs for information and knowledge. Web based technology also provides access to many kinds of file formats independent of what platform is used. Common web tools and applications are web servers, database connectors, dynamic web page generators, electronic phone books, and publishing tools such as MS Frontpage.

Web conferencing and telephones provide informal and formal opportunities for communication, help users to share and create contexts and enable information interpretation (see section 2.6.2). Telephones, especially combined with facsimile, have been a common tool for enabling cooperation. However, their media richness is often low and a need for visual electronic conferencing has therefore emerged. Virtual meetings where participants can share all Windows based applications in real-time have become more widely used. Document collaboration is an advanced version of the same mechanism where the participants can work at the same time on the same document.

Chat-rooms are electronic versions of Davenport and Prusak's (1998, pp. 90-91) water coolers and talk rooms. Applications with web-cameras are often preferred as it has been shown that seeing each other creates trust (Inkpen and Crossan, 1995), which is necessary for effective knowledge sharing (Davenport and Prusak, 1998, p. 34). This is probably also as close as one can get to face-to-face communication and still meet only virtually.

Knowledge mapping tools

Knowledge mapping tools delineate paths for both the origins and destinations of information. Document management systems are such tools, frequently used to create databases of documents, to classify and index documents automatically and to keep track of different versions of the same document. Information mapping tools also link and map the flow of information that might later be converted to knowledge, e.g. repositories, models, distribution channels, information associated with informal conversations, and paths of external networks (Tiwana, 2000, p. 126). Another kind of tool is scanners and facsimiles that convert paper documents into digital documents for electronic archives.

Electronic yellow pages (also known as knowledge maps) and other pointers to expertise are being created today with intranets as platforms. Davenport and Prusak (1998, p. 77) emphasize that much knowledge will remain tacit. Pointers to people who have some specific knowledge, competence, or experience that can be located by searching for keywords are valuable.

Memory tools

This third technological enabler and category of tools, Memory tools, consists of data sources that feed raw data and information into the knowledge management system. The aim is to store explicit knowledge for future use. According to Tiwana (2000, p. 129), such sources include distributed search and retrieval mechanisms; multimedia content (including informal content such as speech and video clips); various databases such as best practice, reference, and customers; operational and transactional data; transaction reports; bulletin boards; and project management (PM) tools. Most of these terms are well known or self-explanatory, but two are worth further comment.

Project management tools such as Prima Vera, MS Project and firm specific computer based operations systems often allow users to link resources used, to create documents, generate reports, and trace referenced hyperlinks. They also provide a basis for organizing and storing records, notes and other documents from each specific project. Project management systems further provide the opportunity to go back and search for information and knowledge in previous and parallel projects.

Multimedia applications such as video and pictures allow the knowledge management system to capture informal content and some tacit knowledge that could not be captured elsewhere. According to Tiwana (2000, p. 131) videos are especially suitable for capturing complex operations and bypassing the limitations of language.

Knowledge combination tools

Knowledge combination tools, the fourth and final category of technology enablers, are tools with functions such as knowledge mining, linking, search, retrieval, and intelligence tools that make it possible to find knowledge by using intelligent agents and pattern mining. To put it simply: these are tools that pick what the user needs from information and knowledge sources. They make it easier for the individual consultant to manage large amounts of explicit knowledge and to combine information and knowledge from various sources in the memory. Typical tools are push/pull agents, data and text mining, web farming technologies, information indexing and classification, as well as information clustering.

Intelligent decision support systems, case-based reasoning, and contextual information retrieval systems extract historical data and lessons learned from previous operations or projects. Data or text mining tools can extract trends and patterns from data warehouses, and external information retrieval systems can extract data and information from the business system of the organization. Previously, expert systems linked to best practice databases have been used in attempts to capture tacit knowledge, although many such attempts have failed ultimately because of difficulties in updating the systems. Expert systems have therefore been criticized in recent years (e.g. by Davenport et al., 1998).

Intelligent agent-based tools are software that package information and provide it as knowledge to specific users either by pull or by push. Tiwana (2000, p. 137) states that packaging knowledge ensures that what is collected proves useful, provides value, encourages application of that knowledge to address actual business issues, and figures in critical decisions. It is therefore assumed that packaging will include filtering, editing, searching and organizing. Searching will then continue simultaneously in the organizational memory using transaction databases, data warehouses, discussion databases, document databases, informal media and as far as possible the minds of people through knowledge maps, competence databases and e-mail in order to keep updated.

2.8 Summarizing a model for the study of knowledge management in technical consultancy organizations

After now having given an overview of major contributions to the literature on professional service organizations and knowledge management, it will be appropriate to describe the framework for the empirical investigations and the analysis of findings. It is assumed that the professional service organization provides services, consisting of packaged and refined knowledge, through special processes carried out or managed by professionals. Such processes include transfer among individuals of knowledge that may have been gained in recent projects or current parallel projects. This knowledge can be tacit or explicit and may be a part of an interchange between explicit knowledge that is easier to transfer and internalized tacit knowledge that is ready to use. Technical consultant organizations are assumed to select one of four basic strategies (delivery, experience, ambition or ideas, cf. section 2.2.2 above) as a reaction to their business context. The choice of strategy acts as a filter for selecting knowledge management efforts. These efforts are derived from business strategy needs, and each effort is linked to enabling conditions and facilitating activities for learning and knowledge transfer (cf. section 2.7). There are six types of enablers: organizational structure, communication and the monitoring of strategy, process, culture, systems for training and learning, and technology. Strategies and enablers can be linked to one or more sub-processes of the knowledge transfer process, which is constituted by five sub-processes: acquisition, distribution, making meaning, organizational memory, and retrieval.

In a broader sense, transfer of knowledge can be assumed to be the core business process in technical consultancy organizations. The knowledge transfer process begins with acquiring information or knowledge that will be needed to carry out an assignment. This particular knowledge can be used by an individual consultant or discussed with other consultants. Independent of whether it is discussed or not, individuals who acquire information must interpret the new information and put it into a context for it to become knowledge. In technical consultancy organizations, discussion with other consultants then usually occurs within the project team but can take place with external experts who are not members of the team or with colleagues in the corridor, in other departments or offices. That particular knowledge will thereby be distributed to others and collectively interpreted, analysed and given a shared meaning though discussion or action.

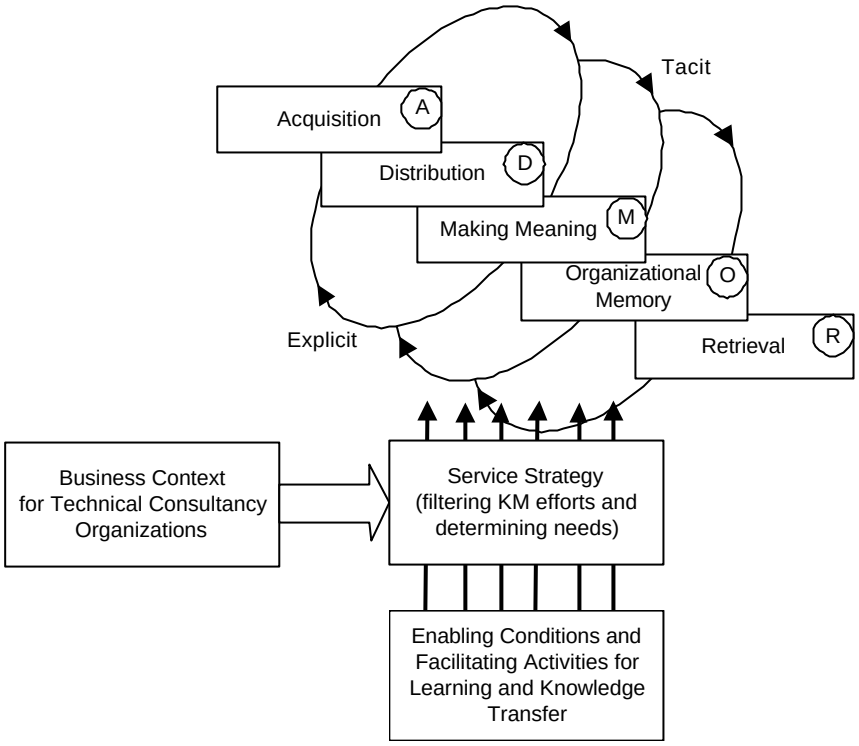

Figure 2.9 A model of knowledge transfer in a technical consultancy organization.

Some knowledge, particularly tacit knowledge, is difficult to articulate and discuss and needs to be viewed through one or more externalization processes. Communication and collaboration are crucial to such processes, and it is important that the organization can provide both an organizational and a technical environment that enables communication. Once given a meaning, knowledge can be stored in some kind of memory. Organizational knowledge, available to members of an organization[18], can be said to be memorized and included in the organizational knowledge base. That particular knowledge can later be retrieved by organizational members who search for it, discuss it with a knower or read it as information, and eventually give it a meaning so it also becomes knowledge in the new context.

Just as for communication, the organization can enable and facilitate learning and knowledge transfer within the organization. Six categories of organizational enablers and four sub-categories of technological enablers have been identified from the literature on organizational learning and knowledge transfer. Depending on what strategy the organization chooses, different enablers and facilitators have greater or lesser importance.

[18] Since technical consultants are information and knowledge intermediaries, knowledge transfer refers to both intraorganizational (individuals belonging to one or another units of the same organization) and interorganizational (individuals belonging to separate organizations) transfer.

3 Research issues

This short chapter discusses the objectives formulated in Chapter 1 in the light of what was learned in the theoretical frame of reference in Chapter 2. It raises eight research questions that are analysed and discussed in the subsequent chapters.

A framework for understanding the conditions for managing knowledge in professional service firms has been proposed. By necessity this included a broad and complex review of knowledge transfer and how it can be facilitated. The review does not claim to cover all issues about transferring knowledge in professional environments. Instead, it provides a specialized view from a process perspective that harmonizes with the construction technical consultancy firm as an information and knowledge intermediary.

Professional service organizations such as technical consultancy organizations have been keenly aware that they are in the knowledge business for decades, and have long focused on developing their abilities to leverage knowledge. They also fully understand that their relationships with clients are the foundation of their business. Thus, many consultants agree that something has to be done to achieve better pay for work performed. Prices of consultancy services for the Swedish construction sector have fallen during the latest ten years, and clients now prefer fixed prices for whole assignments instead of the previous system of payment for the number of hours worked. Similar to other professional service organizations, technical consultancy firms have an interest in the recent trend of managing knowledge in order to be competitive. A number of questions are raised pursuant to the first objective of this investigation: *how do technical consultancy firms serving the construction industry transfer knowledge?*

Generally, professional service organizations focus their resources on very narrow fields of expertise, gain experience across a diverse range of clients, and create new knowledge in the course of their assignments. Both individuals and the organization are able to develop a greater depth of knowledge than their clients, which may be one good reason for using them. Client organizations find it effective to bring in a professional service organization when they require highly specialized knowledge. Large professional service organizations are able to bring together many experts in various fields and therefore, in an organizational sense, become “knowledge generalists” to their clients. When trying to become experts in many fields, organizations run the risk of ending up stuck in the middle of the four strategies for technical consultancy firms discussed in section 2.2.2. A communicated organizational intention and responsibility of managing knowledge will therefore guide the

employees to achieve the organizational goals, it is believed. This raises three questions: (1.1) are there some kinds of knowledge that are perceived as crucial for the organization and, if so, what kinds and why? (1.2) is there a well known intention such as a strategy or shared vision that supports learning and knowledge transfer? and (1.3) is it possible to identify any employee who is appointed as responsible for knowledge management efforts?

Knowledge transfer is more difficult in large, geographically dispersed organizations where the personnel do not meet each other or do not even know each other. Such organizations also have the largest knowledge base and therefore have much to gain by making it available to all its members. In a reliability and brand perspective, it is also important for such firms to have a standardized appearance on the market to show that what is provided is the accumulated experience and knowledge of the organization, not only the knowledge of individual consultants. From the literature review, it can be concluded that large organizations have the most to win from knowledge management efforts, and that they have the largest capability and resources for realizing such efforts. Many clients also expect that such firms are experts in transferring knowledge to the client organization, especially in international assignments.

However, research has not yet explored how these technical consultants manage knowledge as individuals or as organizations. In relation to the first objective, it would be of interest to (1.4) understand which methods in the sub-processes of the knowledge transfer process are preferred by the consultants. There might also be hidden patterns of explanation depending on various background variables such as age, function and formal education. The age of consultants was, for example, discussed in Chapter 1 and it was found that the average age was high and that many consultants were going to retire within a ten year period.

Nor has research explored how knowledge management initiatives in technical consultancy firms facilitate knowledge transfer within the firms. It has been indicated that there are needs to implement new kinds of technological process support tools as well as to make organizational arrangements that support knowledge management. In order to find and understand further generic characteristics and managerial implications a firm faces when striving to take advantage of its knowledge, the enabling conditions and facilitating activities identified in section 2.7 have to be empirically investigated. The question to investigate is (1.5) which mechanisms enabling and facilitating learning and knowledge transfer are in use and how they are perceived by consultants. It is also of interest (1.6) to know what obstacles are perceived as being most common when implementing knowledge management initiatives.

Chapter 1 explored the idea that the work of technical consultants has been much the same since these firms began to grow in the late nineteenth century. IT has made it possible to make far more sophisticated calculations than a hundred years ago. New specializations such as building services engineering and environmental engineering have been added to traditional consultancy but these too use the traditional way of carrying out their assignments. CAD technology has changed the division of work and the functions but not the principles of engineering yet, although simulation tools and parametric design are beginning to change these, too.

In section 1.4.5, it was concluded that technology change leads to development of new process support tools. Such tools are also assumed to enable the creation and transfer of knowledge as discussed in section 2.7.2. Introduction of web technology may be one important enabling mechanism also for gradually changing the principles of engineering. Compared with previous IT tools, web technology has an integrating function and an easy user interface. But it is not yet known how widely implemented or used web technology is and what other IT tools are presently in use. The second research objective is related to process support tools. It concerns the use of process support tools and how they can enable transfer of knowledge within technical consultancy firms: *what is the role of process support tools in enabling transfer of knowledge within technical consultancy firms?* The first step towards achieving this objective is to survey (2.1) what kinds of process support tools are available and in use in these companies and the second is to understand (2.2) how these process support tools are actually used for transferring knowledge.

4 Research method

In this chapter, the research methodology is discussed. The discussion begins with a justification for the choice of overall methodology, followed by the choice of more specific methods. The third to the fifth sections of this chapter discuss the first empirical study (1997-98), beginning with the selection of the four companies and the departments that were studied, followed by a discussion of methods used for data collection and analysis of data. Correspondingly, sections six to eight deal with the second study (2000). Finally, correlation analysis and factor analysis, as used in both studies, are covered.

4.1 Interplay between theory and practice

Generating theory and concepts while exploring the implications of existing concepts from related areas are central activities in research on design management in construction. Such creation of theory and concepts assumes an interplay between theory and practice. On the one hand there is the process of producing research results and on the other hand there is the process of solving practical problems. Developing concepts well accepted by both academics and practitioners is therefore essential. Practical use of research results depends greatly on how firmly established theoretical concepts are in practice. Practice is what the practitioners do, after they have interpreted and made meaning of available information and knowledge. The function of research can be analysed as a special case of knowledge management. Referring to the knowledge conversion process of Nonaka (1994), knowledge must be internalized before it can be used in practice. Two issues can be raised that are important for generating results easier to accept: (1) the research process and how results emerge from practice and are anchored in theory, and (2) the ability of the researcher to understand and make meaning of the objects studied. It is unusual in the field of knowledge management for researchers to have collected a strong empirical data base to use for analysis and theory generation. Published articles often lack empirical foundation or are based on one or two case studies.

The aim of this investigation is *to create an understanding of how technical consultancy firms serving the construction industry manage knowledge*. From a methodological perspective, another aim is to confront the empirical results with well known theoretical concepts in the field.

This investigation is designed to provide a basis for further study of the field of knowledge management in technical consultancy organizations, not only

for those who serve the construction sector. The research method used can be said to be based on abductive reasoning (Alvesson and Sköldberg, 1994). This research method implies a combination of, and alternation between, induction and deduction. The choice of theoretical framework and empirical methods in the present investigation can be seen as a development from an earlier study of contingencies and project coordination in five Swedish technical consultancy firms serving the construction industry (Sverlinger, 1996). This earlier study indicated that organizational measures of coordination tended to be avoided by both the project organization and the permanent organization, other measures being taken instead to raise efficiency. A lesson learned from this study was that it would be fruitful to focus on organizational learning. Initially, the present investigation was based on an extensive review of the literature on organizational learning, which provided a formative input for the 1997-98 empirical study of consultants, to be presented in chapters 5 and 6. When the results from the 1997-98 study were analysed, they pointed in the direction of an approach that would combine organizational learning with principles of knowledge management. The subsequent review of the field of knowledge management and the total frame of reference finally chosen has been presented in Chapter 2. It is this framework that determined the collection of empirical data in the 2000 study that will be encountered in chapters 5 and 7. Thus the framework and the investigation as a whole has evolved in distinct steps, due to the addition of empirical surveys and related fields of thought.

A second issue is addressed by the answer to the question: why study soft topics such as learning and knowledge management at a university of technology? Conducting management research at a technical university brings the researcher close to subjects related to technology, and especially to information technology. Technology is also an important issue for the organizations studied, and knowledge about working methods and output in the organizations studied is crucial to understanding such organizations. However, it can also be claimed that too much knowledge and familiarity with the object studied, in this case technical consultants in construction, makes it difficult to collect data as an unbiased observer. Nevertheless, being a management researcher with a background as a civil engineer carries an advantage when interviewing consultants, reducing ambiguity and making meaning of information and knowledge acquired.

4.2 Choice of research method

Within the studied area, narrowly understood as knowledge management in technical consultancy organizations serving the construction industry, there is no established research tradition. Researchers have previously studied learning

in the construction industry from a general perspective, preferably using case studies (Ericson and Johansson, 1994; Müllern and Östergren, 1995; Boyd and Robson, 1996). More recently Matzdorf and Price (2000) have published a broader quantitative study with a large sample of UK firms representing the chartered surveying profession, which Svensson (2000) has contributed with a study of a large number of projects with knowledge transfer in Swedish cross-border consulting operations in construction.

Interviews and questionnaire surveys are typical of these investigations. Ericson and Johansson (1994) have studied the construction industry from a cultural and sociology of knowledge perspective using interviews. Müllern and Östergren (1995) used case studies to investigate learning as members of an organization changed interpretations during change projects. First they applied a behavioural (social) perspective with a focus on which changes learning leads to; subsequently they used a cognitive perspective with a focus on the learning process. Interviews and semantic analysis were their main methods. Boyd and Robson (1996) describe barriers for learning in the UK construction industry. They conducted two project case studies using personal diaries and debriefing, which builds on reflection with help from the researchers. Matzdorf and Price's (2000) quantitative study of barriers to organizational learning in the chartered surveying profession was based on 281 questionnaire responses. The respondents were asked to evaluate their learning according to a learning framework of 11 characteristics proposed by Pedler et al. (1996). In his recent study of success strategies and knowledge transfer in cross-border technical consulting operations, Svensson (2000) collected information about 458 individual tendering processes as well as information about the firms. Svensson also used case studies in combination with an analysis of almost the entire Swedish export of technical consultant operations in infrastructure during the period from 1995 to 1997.

During the 1990s there were many empirical studies of organizational learning and knowledge management based on multiple cases. Three examples indicate this (Davenport et al. 1996; Hameri and Nihtilä, 1998; Mueller and Dyerson, 1999). Short case studies with semi-structured interviews were used by Davenport et al. (1996) in their study of knowledge management projects in several industries, among them a construction services firm. Hameri and Nihtilä (1998) chose to study five New Product Development (NPD) projects in three different organizations in their study of learning processes and the role of IT support in NPD. Longitudinal case studies performed over a four year period including semi-structured interviews were performed by Mueller and Dyerson (1999) in a study of integration of IT support tools in organizational processes. Recently McAdam and Reid (2000) presented a comparative study of the use of knowledge management in the public and the private sector, based on both qualitative and quantitative data.

Most studies of how practitioners view knowledge management and how they are developing and implementing strategies are done by institutes (APQC, EFQM, KMN, 1997; Chase, 1997) or consultancy firms (International Data Corporation (IDC), 1998; KPMG, 1999). The analysis by Chase (1997) was based on a survey conducted by the Best Practice Club? and the Benchmarking Exchange. The Best Practice Club? is an international network of over 400 organizations, and the Benchmarking Exchange is an international electronic forum for practitioners. Both are dedicated to the exchange of business best practices. Some organizations such as KPMG have done annual surveys, but no public available comparative analyses have yet been presented.

The methods used by APQC, EFQM and KMN were case studies with site visits and interviews in combination with a questionnaire survey. The Best Practice Club? (Chase, 1997) used a postal questionnaire, but only 73 out of 412 questionnaires were completed and returned. The Benchmarking Exchange presented an electronic version of the same questionnaire on their home page and 70 questionnaires were completed (Chase, 1997). In their survey, IDC used a screener questionnaire to prepare for interviews with knowledge management managers in 12 firms. The screener questionnaires used was a good method for ensuring that the respondents were knowledgeable about the topics that would be focused on in the interviews.

Considering this range of empirical studies in the field of organizational learning and knowledge management, it is obvious that a limited number of methods are used. In general, case studies are good to use in situations where the research question has the nature of why, when the researcher cannot control the situation and when the situation studied is in full progress (Yin, 1988, p. 17). Bryman et al. (1988) believe that a qualitative approach gives the interpretation of action, events and perspectives through the eyes of those being investigated. This is said to bring the researcher closer to the reality studied. However, it is often difficult to find underlying patterns without the use of a quantitative approach as well. In the studies of organizational learning and knowledge management referred to, case studies, usually including interviews, are frequently found. Questionnaires are usual in surveys performed by consultancy firms, although questionnaires do not penetrate the topic as deeply as case studies do. It is difficult to find one method that gives both depth and scope. A combination of various qualitative and quantitative methods was therefore resorted to in both the first (1997-98) and the second (2000) studies in this investigation.

The two studies include a broad range of technical consultants serving the construction industry, which should give a deeper understanding of a variety of design specializations in construction. The studies involve roads and

railways engineering, geotechnical engineering, water and environmental engineering, building services engineering, electrical engineering and structural engineering. Moreover, the studies were carried out on a cross-project basis. Primary data were collected from a large number of projects in progress at the same time.

4.3 Choice of objects for the first study (1997-98)

As stated in Chapter 1, the level of investigation is the departmental level and in parts of the analyses the individual consultant. Departments were selected in two steps; first, Swedish technical consultancy groups with an annual (1997) turnover in excess of MSEK 500, of which at least half should relate to work for the construction sector, were identified; second, one department within each consultancy group (company) was selected so that a broad and representative range of technological disciplines would be covered. Applying these criteria led to the identification of SWECO, Scandiaconsult (SCC), Jacobson & Widmark (J&W) and Kjessler & Mannerstråle (KM) and of four departments, one from each company. These departments had already participated in the earlier study (Sverlinger, 1996), where also Ångpanneföreningen (ÅF) had been included. The original choice of departments was thus determined already in 1995 and partly based on suggestions at that time from upper management in these companies. Within each department, all employees were included in the survey, except secretarial staff, but only seven persons across all four departments belonged to this excluded category in 1997-98. For the questionnaire part of the first study, consultants from the same four offices but in related specialist departments were added to the population (see section 4.4.3).

4.4 Collecting data for the first study (1997-98)

Transfer of information and knowledge can be seen as a subtle and continuously evolving process. Relying on traditional methods like interviews and questionnaires as a basis for analysing the transfer process raises the issue of how the organizational context influences individual attitudes. In organizations and societies, reality may be seen as socially constructed (Berger and Luckman, 1967; Weick, 1979). To understand the subjectivity of reality in an organization it is important to know and understand what happens in the organization. One way of gaining a deeper understanding is to get to know the culture, by studying work and interaction in the organization.

The first study therefore included about two weeks of full time study at one department at each company and all data collection was done by the same

researcher. The first company was studied over a period of four weeks (in September 1997), which made it possible to establish a methodology with a set of complementary data collecting methods. Both detailed background facts and general opinions were gathered in interviews, understanding of work and business processes was supported by observations and formal documents, and a questionnaire to measure the individual perceptions of the environment and learning behaviour was also used. The last of the four companies was studied for two weeks in January 1998 and the last questionnaires were collected in February 1998.

4.4.1 Observations on site

This section discusses the observation methods used in the office, how they were applied, and why.

Walking around and talking

The first set of observations was based on walking around in the office and talking to consultants who were present. Observations were made regarding what projects they worked with, whom they met and worked together with, and what they did. Observations of individual consultants working with their tasks in their rooms were also made every day. The aim of walking around and talking was to understand how consultants worked in projects.

Studying people in meetings and in group work

Because many projects were in progress at the same time, there was usually at least one meeting or briefing for some of the project teams every day. At those meetings, the patterns of interaction within teams was observed, as well as what the participants talked about, and how they talked, sketched and used books, brochures and catalogues. The aim was to study a typical learning and knowledge transfer situation.

Process analysis

Knowing the processes, how projects are organized, and how they evolve was necessary to understand how knowledge is shared and how learning takes place. Analysis of the business processes began with studies of manuals in the general business systems and the quality assurance manuals in which the formal processes were described. A first version of a general process map for assignments was then discussed with experienced consultants who knew the formal process well, but who mostly had their personal adaptations, depending on what kind of project they were involved in. The aim was to understand how consultants worked and what opportunities various activities gave for learning in a wider perspective.

Studying the offices

The offices and their facilities were studied. Computers, networks, copiers and printers were mapped and categorized in order to find out what technological enablers were available and in use. The work space (rooms and office landscapes) was studied in relation to the usual functions of the consultants, the teams, opportunities to hold formal and informal meetings and access to CAD stations and other technological tools. The aim was to study the local environmental conditions for knowledge transfer.

Studying written documents

In addition to the analysis of facilities, access to books, magazines and journals, manuals, quality assurance systems, and intranets were studied in order to find usual and possible sources for acquiring and retrieving knowledge. Lists were made of journals and magazines available at all departments and training courses announced on the intranet and elsewhere were recorded. The aim was to find further environmental conditions for learning, including what explicit sources of knowledge that were available.

4.4.2 Interviews

This section discusses the interviews, beginning with the criteria for choosing respondents, followed by a discussion of how themes for the questions were developed. The 1997-98 study included 31 semi-structured interviews with the same number of respondents. All interviews built on open questions or discussion themes.

Criteria for choosing respondents

In each of the four companies, seven or eight interviews were conducted at each department that had been chosen. Respondents for the interviews were selected with the intention of covering multiple viewpoints. Purposive sampling (Saunders et al., 1997, p. 145) with five criteria for choosing individual respondents was used. First (1), the oldest (by profession) and most senior consultant. Second (2), the youngest and most recently employed assistant consulting engineer. Third (3), the line manager (department or team manager). Fourth (4), one of the female consultants. Fifth (5), two or three other consultants, one of whom was to be a project manager and one a consulting engineer.

Using these five criteria for choosing respondents meant that most of the tasks performed at the department were covered, and different kinds of consultants and ages, genders and functions were represented. This reduces the risk of the general results being biased in terms of any particular age, task, gender, or function.

Developing themes and questions for the interviews

The formulation of themes and questions for the interviews was supported by the literature review on organizational learning and competence development, the principal aim of the first study being to understand how technical consultants learn and how that learning can be enabled and facilitated. The basic list of six descriptive themes included is presented in Table 4.1. One additional theme was given to each of three of the categories of respondents: the most senior consultants were given a theme about industrial change and development, the youngest and most recently employed assistant consulting engineers were given a theme about introduction at the company and how to become a member of the team; line managers were given a theme about market activities and leadership.

Table 4.1 Themes to discuss at all interviews in the first study.

No.	Theme
1.	Describe how one of your assignments usually starts (who does what, who meets whom, information received and searched).
2.	Describe how and why your company and then various employees get involved in projects.
3.	Describe the information exchange and knowledge transfer within projects.
4.	Describe how you reduce uncertainty.
5.	Describe what you usually do when you need knowledge you do not have.
6.	Describe what training or courses you have participated in recently.

After having determined the themes, a series of pilot interviews was performed in 1996 on three Swedish construction technical consultants and two Australian construction technical consultants. It was found that the respondents were more comfortable if they could start talking about their history, how they became technical consultants and were introduced into the profession. Then there followed a discussion about the six themes in Table 4.1. The three interviews with Swedish consultants were recorded on tape. Compared with the Australian interviews it was found that it was much easier in the Swedish interviews to listen and to add follow-up questions without the need to take notes. It also seemed that Swedish respondents were able to ignore the tape recorder just a few minutes after they had started to talk about themselves. The pilot interviews were not used in the later analysis.

The 31 interviews were conducted during the period between September 1997 and January 1998. All interviews were recorded on tape and transcribed for further analysis, with one exception where no tape recorder was used but notes were taken and a fair copy of the notes was written later the same day. Interviewees were given the opportunity to comment on transcripts, but no corrections were suggested.

It can be argued that using interviews as a method for data collection limits the data to what the respondents say they do, rather than what they actually do. Such biases have been reduced in this investigation not only by also using

observation and written sources, but also by asking the respondents for obvious examples within their organizations.

4.4.3 The competence and knowledge questionnaire

The questionnaire in the first study (1997-98) was intended to be a complement to the observations and the interviews. As mentioned earlier in this chapter, at that time the focus of the research was inspired by competence development and learning. After having considered the number of potential respondents and time and possibility to get an acceptable response rate, a self-administered delivery and collection questionnaire (Saunders et al., 1997, pp. 245-248; Neuman, 2000) was chosen. All consultants at each of the four departments constituted the core population; if the number of consultants was lower than 35 in a given department, consultants from closely related specializations at the same office were added to the population. For example, if the core department specialized in road and railway engineering, consultants from a department specialized in traffic planning were added to the total populations.

One advantage of questionnaires compared with interviews is that it is easier to reach a large number of respondents. In addition, questionnaires are more anonymous than interviews and can usually be filled in when it is convenient for the respondent, plus the fact that no interviewer bias is introduced. The section below discusses the design of the questions, the choice of scale and the distribution of the questionnaire.

Designing the questions

The pilot version of the competence and knowledge questionnaire was based on five themes: (1) organizational and environmental conditions for competence development and learning; (2) use of competence; (3) potential for competence development; (4) methods for competence development and learning; and (5) sensitivity to knowledge erosion[19].

An appropriate number of questions had to be chosen. Scott (1961) has found surprisingly little evidence of low response rates in long rather than short questionnaires. Recent work by Rea and Parker (1997) and Neuman (2000) proposes a suitable completion time of less than 15 minutes, i.e. three or four pages for a general population. Owing to the method of distributing and collecting questionnaires in the present investigation, there should have been

[19] A Swedish source of inspiration for phrasing questions regarding competence and learning has been a study by Nilsen and Högström (1994).

no disadvantage in choosing about 80 questions, taking between 15 and 20 minutes to answer.

For each of the five themes a set of questions was developed. Domain specific questions on organizational learning and methods for competence development were included. Questions were placed logically, and related questions put together in order to avoid confusion. After having created a pilot version of the questionnaire it was tested on three consultants at one of the companies. As a result of the test, a few questions were re-framed to avoid confusion. The final version contained 66 questions or assertions where the respondents were to mark their responses on an ordinal scale. Further, there were five questions added where the respondents had to formulate their answers. The 71 questions and assertions were finally supplemented with 7 questions about personal data (gender, age, function, years of experience of the same kind of work, period of employment in the company, formal education, what kind of task that the respondents mostly perform) in order to be able to discern categories of respondents. The full list of 71 questions and assertions, translated from Swedish, is given in Appendix 1.

Choice of scale

In the social sciences it is common to use reply alternatives measured according to a scale to transform qualitative into quantitative measures. Goode and Hatt (1952) gave an early and influential description of the scaling technique problem and, more recently, an overview has been presented by Neumann (2000). In the present study, all respondents had to react to questions and their agreement with assertions according to a ten-grade ratio scale (Likert style scale, see Likert, 1932) supplemented with verbal anchors inspired by Borg (1982), see Table 4.2. The verbal anchors are intended to ensure that the respondents feel that they are replying on a scale with equal distances between the reply alternatives. The same scale was used for all attitude questions and assertions in order to avoid confusing the respondents, as recommended by Kervin (1992).

Table 4.2 Ten-grade scale used in combination with the questions and assertions.

Yes very much		Yes largely		Neither nor		No just slightly		No not at all	
10	9	8	7	6	5	4	3	2	1

Although the questionnaire contained five themes with multiple Likert scale questions, they were not combined into indices to measure each of the five themes as single constructs. Instead a single-item scale was used.

Distributing the questionnaire

The questionnaire was introduced in the companies during the first of two weeks of observation. A covering letter was added to the questionnaire in which respondents were informed about the researcher, the study and what the results would be used for. In each of the four studied companies, there were between 12 and 20 consultants at the selected core departments. In order to reach the predetermined number of employees in each company, it was necessary to expand the study to consultants working at neighbouring departments with closely related fields of specialization. This explains why one or more additional departments were engaged in the study.

The questionnaire was introduced at each department two days after the observations began. This was done at a meeting, which approximately 75 per cent of the consultants had the opportunity to attend. After this introduction, the questionnaire was distributed in the personal mailboxes so that those who could not attend the introduction would not miss the questionnaire survey. The questionnaire was anonymous, which made it impossible to remind any individual consultant who, for any reason, had not returned the questionnaire. However, it was possible to remind those employees who were present at coffee breaks and by e-mail. During the two weeks of continuous observation there were many opportunities for consultants to ask questions or demand clarifications, which one or two at each department did.

The questionnaire was distributed to all 140 consultants at the departments studied, and 101 completed the questionnaire and returned it. This gave a response rate of 72 per cent, which was better than expected. Saunders et al. (1997, p. 247) consider the interval of 30-50 per cent to be a reasonable response rate for delivery and collection questionnaires.

Most of the consultants who revealed that they had not responded to the questionnaire said they would answer, but not right at that point of time. They would claim that they were busy and had no time for completing the questionnaire. The general impression from the self-identifying non respondents was that they did not belong to any particular group in terms of age, gender and other background variables. However, as many of those belonging to the 28 per cent non-response group said they did not have time, a bias may have been introduced that may affect survey results, as the consultants who were less busy appear to have been those who completed the questionnaire.

4.5 Analysing data in the first study (1997-98)

This section discusses the use of descriptive statistics for the first study. It begins with the issue of aggregating data from the four companies, followed by a short presentation of the descriptive analysis.

4.5.1 Aggregating questionnaire data

The complexity of identifying how attitudes to learning and knowledge transfer interact with organizational and technological conditions makes it desirable to work with a large number of respondents as a single population. This section discusses whether it is acceptable to aggregate individual responses across companies and departments. It could be argued that differences in organizational culture, or differences between various specializations in building and civil engineering, would lead to different patterns of interaction and thus reduce the validity of the results if these are based on an aggregated analysis. The alternative was to present four case studies, one for each company. However, this could introduce even larger biases when statistical analysis was performed on a limited number of respondents from each company, between 21 and 30. There is an impression of basic homogeneity across companies and departments: the history of these four companies, the educational background and age structure of present staff, the facilities they occupy and use, as well as the office atmosphere, work patterns and client relations during the observation period.

However, there are two aspects where it is likely that there are dissimilarities between the departments studied, and which may need separate discussion. The first aspect is organizational culture and the second is category of technology (specialization). The second aspect is conspicuous when comparing consultants working with buildings and consultants working with civil engineering projects.

No differences in questionnaire responses that would reveal the presence of markedly different organizational cultures were immediately apparent, nor could such differences be observed during the field studies. Schein (1985) sees unconscious beliefs and assumptions steering the values and through them, the artefacts and actions in day-to-day behaviour of the organization as manifestations of organizational culture. When it comes to studying real differences between cultures in organizations, Schein (1996a) assumes the basic assumptions and values have to be revealed. The most important expressions of organizational culture related to assumptions about learning and knowledge transfer can be said to be (1) conditions that encourage risk taking and experimenting (Hedberg, 1981; Nevis et al. 1995); (2) values that permit employees to act autonomously (Nonaka and Takeuchi, 1995); (3)

assumptions of a climate of openness (Nevis et al., 1995); and (4) seeing changes as opportunities for learning (Nevis et al., 1995).

Five variables in the first survey correspond closely to these four expressions of organizational culture and could therefore be used to test for distorting effects arising from differences in culture. To test for differences among all the four companies for the five variables, an extension of Mann-Whitney's test, Kruskal-Wallis' analysis of variance with ranks, was used. This procedure tests for several independent samples and compares two or more groups of cases on one and the same variable. This test is suitable for testing variances in ordinal data, and the form of distribution of the data does not need to be specified.

To compute the test for one variable, the ordinal scale values from all respondents in all four companies were combined and ranked from the smallest to the largest value. For each of the four companies the ranks were summed and the mean ranks for each company were computed by dividing the sum of ranks for each company with the number of respondents in respectively company. A statistic *H* (Kruskal-Wallis *H*) was computed (for formula, see Blalock, 1979, p. 368) in order to mesure the degree to which the various sums of ranks differ from what would be expected under the null-hypothesis. In this case there was more than five respondents in each company. This implies that the recommended (Blalock, 1979, p. 367) sampling distribution was approximately chi square. If the Kruskal-Wallis *H* is significant at the 0.05 level recommended by Blalock (1979, p. 369) the null-hypothesis can be rejected, implying that there was at least one significant difference between the companies. The test was then repeated for the other four variables and the large *P*-values presented in Table 4.3 from using Kruskal-Wallis' test suggested that there were no significant difference at the 0.05 level between the companies.

Table 4.3 Variables that address cultural issues of importance for knowledge transfer (1997-98).

No.	Variable	*P*-values from asymptotic test using Kruskal-Wallis *H*
1	I plan my work.	0.821
9	My work contains elements of new demands and challenges.	0.102
28	Suggestions and proposals are taken seriously at my company.	0.659
29	New ideas and initiatives are encouraged.	0.899
36	Most changes at work are stimulating and provide new opportunities.	0.140

The second aspect of expected differences between the companies was according to specialization, particularly building related services and on the other hand civil works. In this case, too, there are some variables where larger differences could be expected. When performing services related to buildings and civil works, there are different specialists involved. In the case of buildings the architect plays a greater role than in civil works such as roads and railways. However, landscape architects have gained a more prominent

role in such projects in recent years when environmental issues have been more emphasized. User interaction can also be said to be much more common in the case of buildings. Customization is more advanced and not only the client, but also the client's customer, the user, is often expected to define needs. With different specializations, the pattern of interaction between specialists can be expected to be different, as well as the sources of knowledge acquisition.

Three variables were closely related to knowledge acquisition and the pattern of interaction discussed above. When analysing variable 55, learning from contact with users, with Kruskal-Wallis' test of variance, a significant difference (*P*-value lower than the recommended 0.05 level) was found between the companies (see Table 4.4). Studying the mean ranks for each company, it was found that one company had a much higher mean rank than the other three companies. The divergent company had an arithmetic mean value of 1-1.5 unit (on the 10 grade Likert-style scale) more than the other companies. The constructed facilities based on the outputs from this kind of specialization is much more obvious to the users in everyday situations than constructed facilities based on the outputs from the services the other three specializations provide. Learning from contact with users and this particular specialization will therefore be discussed separately in Chapter 6.

Table 4.4 Variables that address specialization issues of importance for knowledge transfer (1997-98).

No.	Variable	*P*-values from asymptotic test using Kruskal-Wallis *H*
55	I learn things I can use in my work from contact with users.	0.031
57	I learn things I can use in my work from contact with other technical consultants.	0.198
58	I learn things I can use in my work from contact with architects.	0.001

For variable 57, Kruskal-Wallis' test of variance shows that there is no evidence of significant (0.05 level) differences between the companies. For variable 58, about acquiring knowledge from architects, the test showed a significant difference with a *P*-value lower that the recommended the 0.05 level (see Table 4.4). It is clear from the analysis of mean ranks that the differences occurred between services related to buildings and services related to civil works. This indicates that knowledge acquisition and interaction with architects must be discussed separately for buildings and civil works.

Differences between the companies are thus mainly attributable to specialization. Keeping this limitation in mind, it should be acceptable to aggregate individual questionnaire responses and treat them as an integer whole.

4.5.2 Descriptive analysis

The descriptive analysis contains data from the observations and interviews as well as from the questionnaire. It aims at providing an overview of the current state of knowledge transfer during the autumn of 1997 and early winter of 1998. The number of respondents (N), mean value (Mean), and standard deviation (SD) is presented for each of the variables in Chapter 6. A few responses to individual questions appear to have been left out by mistake by respondents, but no pattern was found. Missing values have therefore been replaced in correlation and factor analysis (see section 4.9) with the mean value for each variable.

4.6 Choice of objects for the second study (2000)

In order to perform a comparative analysis the same companies and the same departments were selected for the 2000 study as in the first (1997-98) study. Between the studies, two of the companies had reorganized at the department level. In one company what had previously been two departments were merged into one department, principally keeping the same personnel except for the usual retirements. At the second company three departments had been reorganized and employees had changed departments so that employees with very narrow specializations and kind of assignments now worked at the same department. However, in spite of these changes, the employees across all three departments were almost the same as in the first study. It can therefore be concluded that almost the same individuals who took part in the first study took part in the second study as well. The only exceptions were a few people who had retired and a few who had recently joined the departments.

4.7 Collecting data for the second study (2000)

During the period of two years between the studies, the research focus of the investigation had changed. As outlined in section 4.1, moving from competence development and organizational learning, the new focus was closer to managing knowledge, where learning can be seen as a considerable component. More emphasis was also put on the quantitative data and analysis. Mechanisms enabling learning and knowledge transfer were identified from the literature (see section 2.7) and a plan was drawn up to study them in the companies. It was decided that a research design including both interviews and a second questionnaire would be suitable, because questions that could be answered easily by just one or a few employees were included in the interviews, and questions about perceptions of what the consultants do at work were included in the questionnaire. The second study began with

interviews in February 2000 followed by questionnaires in March. The interviews were finished in April 2000 and all questionnaires were also collected during the same month.

4.7.1 Interviews

Similarly to the interviews in the first study, the interviews in the second study were based on open ended themes leading to discussion. It was decided that the interviews should provide a background to what had happened during the time between the studies, particularly in the field of managing knowledge. In this section the choice of respondents and the development of interview themes are explained.

Choosing respondents

Again, the employees to be interviewed were chosen so that it would be possible to get multiple viewpoints. Three categories of respondents were selected. First, there was to be a functional manager at top corporate level from each company who could present strategies and organizational measures to manage knowledge from the perspective of top management. Second, there was to be an IT expert who could explain how IT is supposed to support the operational tasks and its role in managing knowledge at each company. Third, the line managers at the four departments were to be included.

A total of thirteen employees were interviewed. Six were interviewed at their offices, three by telephone and four were interviewed at Chalmers University of Technology.

Developing themes and questions for the interviews

Starting with research question 1.5, 2.1 and 2.2 (see Chapter 3), new themes and questions were developed from the literature review on knowledge creation and transfer as well as organizational learning. The themes (see Table 4.5) were structured according to the review of enablers and facilitators of learning and knowledge transfer found in section 2.7.

Table 4.5 Themes to discuss at the interviews in the second study.

No.	Theme
1.	Organizational structure
2.	Communication and the monitoring of strategy
3.	Process
4.	Culture
5.	Systems for training and learning
6.	Technology
6.1.	Knowledge transfer tools
6.2.	Knowledge mapping tools
6.3.	Memory tools
6.4.	Knowledge combination tools

The first intention was that respondents should discuss those themes that they were more familiar with. Most of the themes were discussed with more than one respondent at each company. For IT related themes, the IT expert contributed most, but department managers also contributed on issues that concerned their departments and specializations. Notes were taken and the researcher made a fair copy of the notes on the same day the interview was made.

4.7.2 The knowledge transfer questionnaire

The aim of the questionnaire was to survey recent behavior in the area of knowledge management and to provide an opportunity to compare findings with those from the first study (1997-98). The questionnaire measures the individuals' perceptions of situations, conditions and tools described in the questions and assertions presented to them. In order to facilitate comparisons with the first study and to avoid confusion, the original ten-grade scale was kept unchanged for all themes but two, themes 4 and 6 (see Table 4.6), which were new in the second study and where a nominal (category) scale was used.

Designing the questions

When designing the second questionnaire there were two main issues to consider: (1) the possibility of comparing with the first questionnaire, and (2) the desire to create an understanding of how knowledge is seen as being transferred, and how transfer was enabled and facilitated. The first issue was dealt with by the use of recurring questions. However, not all questions from the first questionnaire were relevant. First, the open questions about courses, training, and trade associations were excluded. Second, six questions about the quality assurance system and four questions about the sensitivity to knowledge erosion were excluded because they were not specifically relevant to the new research focus. Third, another eight questions were excluded because analysis of responses from the first questionnaire revealed that they had high significant correlations at the 0.01 level to other variables related to the same phenomenon. One such example is learning by participating in training and courses, which was highly correlated with learning from both external (0.50)

and internal courses (0.32). Fourth, the final four excluded questions were related to job characteristics, found in the first theme in the first questionnaire (1997-98), also less relevant to the new research focus. A total of 45 of the 66 questions (with answers on a ten-grade scale) from the first questionnaire were thus repeated in the second questionnaire.

The second main issue was addressed using the model of the knowledge transfer process developed in Chapter 2. First, particular questions and assertions about the knowledge transfer sub-processes were asked. The sub-process of making meaning was difficult to mirror properly in the questionnaire. This sub-process was to a large extent included in questions and assertions about distributing knowledge and information, and it could also be reflected in assertions about organizational conditions. Second, perceptions of the enablers and facilitators were surveyed. A special emphasis was put on technological process support tools. The questionnaire therefore grew to contain 14 themes, each with 4-30 questions (see Table 4.6 for the themes included and Appendix 2 for all the questions in translation). The total number of questions in the second questionnaire was 193. Theme 6, about storing knowledge and organizational memory, was to be answered (yes/no) according to a nominal scale including 13 categories of knowledge storage and more than one category could be answered for each question. This theme was therefore coded in an 11x13 matrix containing 143 (yes/no) variables to be statistically analysed.

Table 4.6 Themes included in the second questionnaire.

No.	Themes	No. of questions
1.	Purposeful attempts to transfer knowledge	19
2.	Perceptions of how useful various methods/sources are for knowledge transfer	30
3.	Access to knowledge	4
4.	Distribution of knowledge to different hierarchical levels	11
5.	Knowledge categories assumed to be crucial within the company	11
6.	Organizational memory, where various knowledge categories are believed to be stored	11
7.	Use of the intranet	10
8.	Willingness to manage knowledge	5
9.	Organizational conditions for managing knowledge and perceptions of the use of knowledge	21
10.	To what extent various technical process support tools are used	18
11.	The importance of various technical process support tools	18
12.	Perceptions of various technical process support tools	10
13.	Perceptions of the organization's knowledge management objectives (ambition levels)	7
14.	The most frequent obstacles in creating and transferring knowledge	18

After the questionnaire was distributed, the questions in themes 1, 2, 3, 8, and 9 were reassigned to new themes before the analysis, in order to achieve better consistency with the theoretical model. Table 4.7 shows the relation between all themes in the final version used for the second survey, together with the relation to research questions formulated in Chapter 3. Many questions in the original themes 1 and 2 were assigned to more than one of the new themes of (1) knowledge acquisition, (2) knowledge distribution and making meaning

and (3) retrieval of knowledge. The resulting pattern is displayed in Tables 7.2, 7.5, and 7.10.

Table 4.7 Final version of themes from the second questionnaire, related to research questions.

No.	Final theme	No. of questions	Research question
1.	Knowledge acquisition	27	1.4
2.	Knowledge distribution and making meaning	20	1.4
3.	External knowledge transfer	5	1.4
4.	Knowledge retrieval	8	1.4
5.	Distribution of knowledge to different hierarchical levels	11	1.4
6.	Knowledge categories assumed to be crucial within the company	11	1.1, 1.4
7.	Organizational memory, where various knowledge categories are believed to be stored	11	1.4
8.	Use of the intranet	10	2.1
9.	Personal characteristics related to potential for organizing knowledge transfer	13	1.5
10.	Job characteristics related to organizing work	4	1.5
11.	Organizational enablers and facilitators	19	1.5
12.	Technological enablers	2	1.5
13.	To what extent various technical process support tools are used	18	2.1
14.	The importance of various technical process support tools	18	2.2
15.	Perceptions of various technical process support tools	10	2.2
16.	Perceptions of the organization's knowledge management objectives (ambition levels)	7	1.2
17.	The most common obstacles in creating and transferring knowledge	18	1.6

Distributing the questionnaire

The delivery and collection method used for the first questionnaire was refined in the second study. In all four companies, all employees at the selected departments were called to a meeting held in their office during working time. At the meeting, the questionnaire and a covering letter were handed out to each respondent. After an introduction of the questionnaire and its objectives the respondents had to fill out questionnaires and leave them at the table before they left the meeting. Having respondents to fill out the questionnaire during the session is a way to minimize confusion and improve accuracy. Respondents could ask questions if something was difficult to understand. Only one or two questions were raised at each company. It took between 18 and 32 minutes to complete the questionnaire. Next, 33 questionnaires (with stamped envelopes) were given to the administrative personnel to deliver to those who did not attend the meeting. Only three of those questionnaires were returned.

Thus, the questionnaire was distributed to 139 consultants, 109 of whom completed and returned the questionnaire. This gave a response rate of 78 per cent. No detailed analysis of those 33 who did not attend the meeting has been made. Only one meeting was held at each company and there are always some consultants out on assignments, although the time for the meeting is well known. A few consultants were unable to attend the meeting for health reasons.

Compared with the distribution method used for the 1997-98 questionnaire, the risk of introducing biases from the group who did not respond to the 2000 questionnaire is different. Consultants who are not at the office are often

attending meetings elsewhere, performing inspections and audits or doing site studies. Project managers usually attend meetings held outside their office. Inspections are done by experienced specialized consultants who are usually older than their colleagues. Site studies are usually performed by a pair of two consultants, usually one sub-project manager or consultant engineer supported by a less experienced assistant consulting engineer (see section 5.1.2). This means that a range of consultants may have had reasons not to be at the office to attend the meeting where the questionnaire was distributed and completed. A slight bias can have been introduced because of a greater tendency for senior consultants to be absent. This may have influenced the pattern of answers to questions that are correlated to age, function, and task.

4.8 Analysing data in the second study (2000)

Similarly to section 4.5 which dealt with the first study (1997-98), this section discusses the analysis of data in the second study (2000). It begins with a discussion of the issue of aggregating data from the four companies, followed by a short outline of how data have been presented as a basis for further analysis.

4.8.1 Aggregating data

Just as in the 1997-98 study, the question should be asked whether it is acceptable to aggregate data from the four companies. Different organizational cultures and different specializations could be obstacles to aggregation. There are five variables in the second questionnaire that particularly address underlying cultural assumptions and values (see Table 4.8). Four of these are almost the same as in the first study and the fifth (variable 9.15) is a replacement for one of the variables (No. 28 in Table 4.3) that did not recur in the second study.

Table 4.8 Variables that address cultural issues of importance for knowledge transfer (2000).

No.	Variable	*P*-values from asymptotic test using Kruskal-Wallis *H*
1.10	We encourage initiatives and experimenting in order to acquire knowledge.	0.182
8.5	Most changes at work are stimulating and provide new opportunities.	0.509
9.2	I plan my work.	0.843
9.4	My work contains elements of new demands and challenges.	0.628
9.15	A climate of openness and trust permeates the organization.	0.269

The Kruskal-Wallis' test of variance showed that no significant evidence at the recommended 0.05 level (Blalock, 1979) of difference between the companies could be found for any of the variables (see Table 4.8).

When it comes to specialization, the second aspect of expected differences between the four companies, the same variables as for the first study were

retained. The observed high *P*-values for learning in interaction with users (variable 2.15) and with other technical consultants (2.16) suggest that there is no significant difference between the companies with respect to those two variables (see Table 4.9). Just as in the first study, one company had a higher mean rank than the three other companies in leaning from interaction with users. This was the same company as in the first study, but this time the difference in mean rank from the other companies is much less, and no separate analysis appears to be needed.

Table 4.9 Variables expected to be different depending on specialization (2000).

No.	Variable	*P*-values from asymptotic test using Kruskal-Wallis *H*
2.15	I learn from interaction (credit and criticism) with users.	0.808
2.16	I learn from interaction (credit and criticism) with other technical consultants.	0.786
2.18	I learn from interaction (credit and criticism) with architects.	0.001

Also similarly to what was found when analysing responses to the first questionnaire, the variable about learning from interaction with architects (variable 2.18) revealed significant (*P*-value 0.001) differences between companies. It is still possible to assume that this difference can be explained by differences in the work of services related to buildings and civil works respectively. Analysing the ranks shows that the two companies where departments specialized in civil engineering were studied had low mean ranks and the two companies where departments specialized in buildings were studied had high mean ranks. It can therefore be concluded that data from individual questionnaires in the second study can be aggregated and treated as a whole, with the exception of knowledge acquisition from architects. For the analysis of that variable, a dummy variable must be introduced that reflects: (1) departments performing engineering related to civil work and (2) departments performing engineering services related to buildings.

4.8.2 Descriptive analysis

Just as for the earlier study, in the descriptive analysis containing data from the (2000) questionnaire, the number of respondents (N), mean value (Mean), and standard deviation (SD) are shown for each variable in Chapter 7. A few variable values appear to have been left out by individual respondents by mistake and no obvious pattern for missing values was found. Missing values have therefore been replaced with the mean value for each variable.

4.9 Correlation and factor analysis

First, the assumptions behind the use of correlation analysis later in Chapter 6 for the first study (1997-98) and in Chapter 7 for the second study (2000) are discussed. Since the analysis in Chapter 8 will rely partly on factor analysis, the

choice of measures of correlation supporting factor analysis and further choices made when applying factor analysis are explained.

4.9.1 Correlation analysis with ordinal variables

Correlation is a measure of association between two or more variables. The purpose of such measures is to show how much the variables co-vary, but it should be noted that this says nothing about causality. It has been debated in the social sciences whether it is correct to use ordinal variables in statistical analysis as if they were interval variables. The distance between ordinal variables cannot be claimed to be as equal as for interval variables. This can cause undesired effects when using the most common measure of correlation between linear variables, Pearson's *r*. This can be avoided by using Kendall's t_b, a nonparametric measure of association for ordinal or ranked variables (Blalock, 1979, pp. 433-439). The sign of the coefficient indicates the direction of the relationship, and its absolute value indicates the strength, with larger absolute values indicating stronger relationships. Possible values range from -1 to 1. Kendell's t_b will be used as the measure of correlation in chapters 6 and 7.

In factor analysis, it is not possible to use Kendall's t_b because the most common method of factor analysis, principal component analysis, is based on Pearson's *r*. As previously mentioned, the use of ordinal variables as if they were interval variables can cause unwanted effects when using Pearson's *r*. However, many researchers have pointed out that the ensuing error in most cases will be small (Labovitz, 1970; Labovitz, 1971; Kim, 1975; O'Brian, 1979; and Zumbo and Zimmermann, 1993). Gaito (1980) goes even further, stating that statistical techniques and measurement scales are not related. Nevertheless, many authors are against using statistics such as Pearson's *r* with ordinal variables (McKelvey and Zavoina, 1975; Townsend and Ashby, 1984; and Townsend, 1990).

Michell (1986) has analysed the different opinions of whether it can be considered appropriate to estimate Pearson's *r* on ordinal data. He concluded that it is not entirely statistically correct, but if the distances between the reply alternatives are fairly equal, such analyses have acceptably small margins of error. The use of Pearson's *r* in combination with an ordinal scale is often found in the social sciences (Adam et al., 1997) as well as in general management research (Gaski, 1996; Ngai and Cheng, 1997) and in studies of the construction sector (Hoxley, 1998; Akintoye, 2000; Chan and Tam, 2000, Holm, 2000). It is therefore assumed that the use of Pearson's *r* in factor analysis does not introduce bias in the conclusions of this investigation.

Results from correlation analysis with Pearson's *r* have been compared here with results from correlation analysis performed with Kendall's t_b. For data from the two surveys, it can be said that correlations generated with Pearson's *r* are about 20 per cent higher than those generated with Kendall's t_b. The implication for the factors extracted is that variables in each factor may be more strongly correlated with each other than if the function had been extracted from a correlation matrix based on Kendall's t_b. In the correlation analysis performed for each factor after it was extracted, the Pearson's *r* correlations were replaced by Kendall's t_b correlations, and each factor was tested for internal consistency using Cronbach's a (Cronbach, 1951).

4.9.2 Factor analysis

In order to find hidden patterns and groups underlying the questions in the questionnaire, and to further analyse them, exploratory factor analysis has been used in this investigation. Exploratory factor analysis seeks to uncover the underlying structure of a relatively large set of variables. The a priori assumption of the researcher is then that any variable may be associated with any factor. Factor analysis will be used (see Table 4.10) in the discussions in Chapter 8, where the results will be compared with results from descriptive analysis.

Table 4.10 Factor analyses and number of contributing variables.

Factor analysis	No. of variables	N
Knowledge acquisition (2000 study)	27	109
Knowledge distribution and making meaning (2000 study)	20	109
Causality of knowledge (2000 study)	11	109
Knowledge retrieval (2000 study)	8	109
Organizational enablers and facilitators (2000 study)	19	109
Use of technological tools (2000 study)	18	109
Recurring variables from the first study (1997-98), using data from the 2000 study	45	109
Recurring variables from the first study (1997-98), using data from the 1997-98 study	45	101
Recurring variables from the first study (1997-98) and use of technology tools (2000 study)	58	109
Obstacles to knowledge transfer and implementing knowledge management initiatives (2000 study)	18	109

Tests of variable fitness for factor analysis

For the first study (1997-98), factor analysis was performed only on questions that recurred in the second study (2000). The factor analysis commenced with a study of the Kendall's t_b correlation matrix of all of the 45 recurring variables. Bryman and Cramer (1999, p. 273) suggest that any variable that is not significantly correlated to any other variable at the 0.05 level should be excluded from the factor analysis. The correlation matrix clearly shows that none of the variables fall into this category. Another condition that needs to be fulfilled for statistical tests of number of factors is that the variables have a multivariate normal distribution. The Kolmogorov-Smirnov test was applied to data from the first study (1997-98) and it was found that four variables (Number 23, 24, 29 and 52, see Appendix 1) were not normally distributed at

the 0.05 significance level. However, all four were very close to the 0.05 level recommended by Gorsuch (1983, p. 148) and were not excluded from the analysis.

For each of the nine factor analyses based in data from the second study (2000), all variables were found to correlate to another variable at least at the 0.05 level of significance. Of the 126 variables in the original themes (numbers 1, 2, 3, 5, 8, 9, 10, and 14, see Table 4.6) that were used for factor analysis, only five were found not to be normally distributed at the 0.05 significance level, using the Kolmogorov-Smirnov test. These variables (numbers 1.2, 1.12, 1.13, 2.5, 9.21, see Appendix 2) had significance levels between 0.10 and 0.22 and were excluded from the factor analysis. The number of variables contributing to the factor analyses are presented in Table 4.11.

Table 4.11 Factor analyses and the reduced number of contributing variables.

Factor analyses	No. of variables	N
Knowledge acquisition (2000 study)	25	109
Knowledge distribution and making meaning (2000 study)	20	109
Causality of knowledge (2000 study)	11	109
Knowledge retrieval (2000 study)	8	109
Organizational enablers and facilitators (2000 study)	16	109
Use of technological tools (2000 study)	18	109
Recurring variables from the first study (1997-98), using data from the 2000 study	44	109
Recurring variables from the first study (1997-98), using data from the 1997-98 study	44	101
Recurring variables from the first study (1997-98) and use of technology tools (2000 study)	57	109
Obstacles to knowledge transfer and implementing knowledge management initiatives (2000 study)	18	109

The reliability of factors emerging from factor analysis depends on the size of the sample, although there is no consensus regarding how large a reliable sample should be. One extreme is represented by Gorsuch (1983, p. 148), who has proposed that there should be at least 100 individuals per analysis and five individuals per variable. However, other autors require considerably less. Foster (1998, p. 207) claims that the number of respondents should be at least twice as many as the variables and Bryman and Cramer (1999, p. 273) assert that the sample should be larger than the number of variables. The number of completed questionnaires in the first study (N = 101) as well as in the second (N = 109) is enough, according to Bryman and Cramer, to perform the ten analyses proposed in Table 4.11. The factor analysis regarding knowledge acquisition and the three analyses on recurring variables including the one with use of technological tools in Chapter 8 will not fulfil the strict requirements proposed by Gorsuch.

Bartlett's test of sphericity tests the null hypothesis that the correlation matrix is an identity matrix. The data must be a sample from a multivariate normal population. If the null hypothesis cannot be rejected, and the sample size is reasonably large, the use of multivariate analysis should be reconsidered, since the dependent variables are not correlated.

The values of MSA (Measures of Sampling Adequacy) must also be reasonably high for a good factor analysis. The Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy is an index for comparing the magnitudes of the observed correlation coefficients to the magnitudes of the partial correlation coefficients. Small KMO values indicate that factor analysis should not be considered, since correlations between pairs of variables cannot be explained by the other variables. Kaiser (1974) characterizes values in the 0.90's as marvellous, in the 0.80's as meritorious, in the 0.70's as middling and in the 0.60's as mediocre and below 0.5 as unacceptable. The 0.6 level was used as a lower limit in Chapter 8, but as could be seen in Chapter 8, most of the factor analyses performed have a KMO in the 0.7-0.9 interval.

Extraction, rotation and interpretation of factors

Two criteria are commonly used to determine the number of factors that should be included: Kaiser's criterion and graphical scree test. When using Kaiser's criterion all factors with eigenvalues greater than one are selected. This means that factors that explain less than one single variable are excluded, because the total variance that any single variable can have has been standardized to one. The graphical scree test proposed by Cattell (1966) is the second method (Bryman and Cramer, 1999, p. 277). In this method, a graph of the descending variance accounted for by the factors initially extracted is drawn. This scree plot typically shows a break at the end of the steep slope. Bryman and Cramer (1999, p. 277) as well as Gorsuch (1983, p. 167), building on observations by Cattell, assert that the group of factors beyond this break, the scree at the gentle slope, is less important since they explain less of the variance. The scree procedure provides a solution in which the minimum number of factors accounts for the maximum amount of variance (Gorsuch, 1983, p. 167). In Chapter 8, factor numbers will be set to the lower of the figures given by Kaiser's criterion or the scree procedure.

The next step in factor analysis is to rotate the factor matrix, a procedure which should make it easier to identify factors. After rotation, the number of larger and smaller factor loadings increases, and variables will be more highly correlated with a single factor and a more meaningful interpretation of the factors becomes possible. Varimax orthogonal rotation was used. It will search according to Gorsuch (1983, p. 185) for a position where the variance is maximized across all factors chosen.

When interpreting the factors, only those variables with a factor loading of greater than 0.4 within each factor, are included in that factor (the criterion proposed by Bryman and Cramer, 1999, p. 280, is greater than 0.3). An alternative criterion, according to Bryman and Cramer (1999, p. 280), is the

correlation above which no variables correlate highly with more than one factor.

5 Context, enablers and facilitators in the four companies

This chapter aims at giving a background to what happened in this part of the Swedish technical consultancy industry during the years 1997-2000, and to add content to the two lower boxes in the model of knowledge transfer in technical consultancy companies depicted in Figure 2.9. The first box contains the business context as earlier discussed in sections 1.4 and 1.6 from a technical consultancy sector viewpoint and again in sections 2.1 and 2.2 in a broader theoretical perspective. In this chapter and particularly section 5.1, the business context is presented as based on interviews and documents from the first study in 1997-1998. In Chapter 2 it was assumed that the knowledge transfer process was performed as a part of the business process. For each activity in the business processes presented, one or more sub-processes within the knowledge transfer process was mapped. Finally, the other box in the knowledge transfer model, containing enabling conditions and facilitating activities, is presented in section 5.2 as based on the more recent interviews and documents from the second study.

5.1 The first study, 1997-1998

The studies at the first company began in August 1997. Markets for technical consultants were improving slightly after several years of recession from 1992 to 1997. During the years of recession, the Swedish government decided to invest in infrastructure such as roads and railways, in order to keep down unemployment for construction workers, and to improve the network of motorways and railways. Those investments also meant more assignments for technical consultants specialized in geotechnics, ground water, roads, railways and bridges. In two of the companies, the studied departments specialized in infrastructure engineering: one was a special geotechnics and ground water department and the other a road and Railway department. In the other two companies, departments oriented towards house building were chosen, which began to improve in late 1997. The selected departments were one department of structural engineering and one department of building services engineering.

As the study began, the quality management trend had lasted for some years and the four studied companies had introduced quality control systems. Two of them had been certified according to the international quality assurance standard ISO 9000. ISO 9000 is well known for its demands on documentation, for example of work processes including reviewing,

verification and validation. As stated by consultants interviewed in the 1997-1998 study, the ISO 9000 documentation system was not in conformity with common practice in technical consultancy work, so the companies had tested several models in the early 1990s (going from strictly rational and normative to more cooperative and guiding) of documentation systems, especially for verification. Personnel were trained and functions such as person responsible for quality in a project and quality manager were introduced. Documentation was kept in an extensive collection of binders, one for each department, supplemented with personal binders and project binders. Companies would have had to put considerable efforts in keeping all binders up to date with changes, time which not all employees may have felt they had. This resulted in outdated binders with various old versions of the quality systems. However, work with quality systems provided a good platform for change and for questioning some of the assumptions behind earlier practices. Thus it served as a precursor for introducing the next systematic approach and certifying arrangement that began gaining acceptance during the first study, the environmental management standard, ISO 14000.

During the autumn of 1997 intranets were introduced in the four companies of the first study. The intranets began with internal information and replaced internal paper based newsletters. The quality system with all its binders was successively replaced by the intranet version, and templates for many kinds of document were made available. As the first study came to an end in early 1998, the intranets were in their first stages and some of the smaller offices still had to access them by modem.

Computer Aided Design (CAD) had been more generally introduced earlier in the 1990s, and was now a standard working method in all new projects except for refurbishment projects where the old paper-based documentation system remained. However, CAD was two-dimensional CAD, not yet object oriented and not yet integrated with other software tools such as calculation programs. Three-dimensional CAD had emerged for steel structures and roads and highways, and a primitive version of object orientation appeared in 1997/98 in the shape of AutoCAD Release 14 with Point 5.0. What was new and interesting from a knowledge management perspective, was that document management standards had begun to emerge, not only for the specific project, company or client, but for the industry as well. An issue raised by more than one of those who were interviewed was the definition and use of the layer structure in CAD files.

From having discussed feedback and reuse of experiences for several decades, focus in these technical consultancy companies now shifted towards more modern terminology such as competence development and knowledge management, concepts that were used by more than one of the interviewed

consultants. Knowledge began to be used as an argument, a selling word, and a proof of seriousness in marketing, while the word also emerged in the annual reports from the 1997 financial year (J&W, 1998, p. 7; KM, 1998, p. 12; SCC, 1998, p. 16; SWECO, 1998, p. 25).

5.1.1 Competence and knowledge

All four consultancy groups studied in this investigation (J&W, KM, SCC, and SWECO) emphasized competence as their most important resource, according to annual reports from respectively group (1998). Hiring new and well-educated personnel was seen as a vital part of the construction technical consultancy firm efforts to meet new requirements for competence. The number of employees with a university degree was high compared to the construction industry as a whole (where the level of education is considered low, see KOMPUT, 1995, pp. 29-30) and homogeneity is high. According to annual reports from 1997, the percentage of employees with university degrees fell in the 30-41 interval: J&W 30 per cent, KM 40 per cent, SCC 38 per cent, and SWECO 41 per cent. Homogeneity was measured by the percentage of employees with a university degree in engineering and employees with an exam from technical college which, also according to the annual reports from 1997, were for: J&W 74 per cent, KM 80 per cent, SCC 68 per cent, while SWECO did not present this information. It should be expected that a high and homogenous educational level facilitates the development of shared mental models and values in companies.

5.1.2 Internal functions

Technical consultancy organizations are, as Maister (1982) emphasizes, flat organizations. According to interviews and internal documents in the four companies, there are usually three levels in the line organization: managing director and other executives, possibly a business area manager (*affärsområdeschef,* or if the company is geographically organized, an area manager, *regionchef,* or office manager, *kontorschef*) and the department manager (*avdelningschef,* in J&W, KM, and SCC) or team manager (*gruppchef,* in SWECO/VBB Viak). It is common to choose a skilled project manager or consultant when a position as line manager is appointed. Below the lowest level of line manager, that of the department manager or team manager, knowledge workers are classified into competence groups, according to what kind of functions they are able to fill in projects. According to the interviews, there was a long learning and socialization process to earn the confidence to fill a more advanced function. Nevertheless, one and the same employee may have different functions depending on the kind of project. The number of assignments to man and access to competent employees are also important

when deciding what function a consultant will have in a project. At smaller departments line managers not only handled client relations and administration, they might fill other functions such as project managers as well.

It was well known in the technical consultancy sector that the processes of the professional technical tasks had not been mapped. In some cases there were a few checklists and overarching descriptions. The traditional functions in a construction technical consultancy company are project manager (*uppdragsledare*), sub-project manager (*handläggare*), consultant engineer (*konstruktör*), and assistant consultant engineer (*biträdande konstruktör*). Other, more specialized functions include person responsible for quality in a project (*kvalitetsansvarig*), quality manager (*kvalitetsledare*), quality auditor (*kvalitetsrevisor*), person responsible for environmental issues in a project (*miljöansvarig*), environmental manager (*miljöledare*), internal auditor (*interngranskare*), computer coordinator (*datorsamordnare*), etc., which usually are combined with the traditional functions. Superior line managers usually appoint employees to various functions on an annual basis.

The project manager is responsible for the assignment within the framework given by the contract. Under the authorized representative, who is usually a line manager, the project manager has full responsibility for technical, environmental, esthetical, administrative, and financial issues related to the project. Project managers carry out the assignment in cooperation with the client organization and other parties according to the contract. Project managers are appointed by the line manager, and some of them are permanently authorized to negotiate for and manage new assignments. It is common in the construction industry that project managers have long-time business relationships with clients and that they win many of the new assignments[20]. Thus they also act as account managers for certain customers.

Sub-project managers work independently under the project manager and are responsible for one or more parts of the project. The project may have been split in terms of physical limits, time constraints, or specialization. The sub-project manager is fully responsible for sub-project technical, environmental, and esthetical issues and is responsible to the project manager in terms of administrative and financial issues for the sub-project. It is not unusual that the sub-project manager runs the work at the office, while the project manager works on client relations and participates in meetings. The line manager and the project manager appoint sub-project managers[21]. The work

[20] The function of project manager is reminiscent of the brain category in the typology proposed by Maister (1982), referred to in section 2.1.3.

[21] The function as sub-project manager resembles Maister's grey hair category, with some overlap with the brain category.

includes some contact with clients and with other consultants in a project. The technical expertise is the same as for project managers.

Consulting engineers work independently under project managers or sub-project managers. They are skilled professionals who know most of the technical work of their profession. They have limited contact with customers and other consultants. It usually takes 2-5 years of full time work after university to become a consulting engineer[22].

The last function is the assistant consultant engineer[23]. Such an employee usually has limited experience of the current type of assignment and works with well-specified tasks under supervision of a more experienced consultant.

Owing to the amount of time it takes for an assistant consultant engineer to accumulate enough knowledge to become a project manager, there is considerable inertia to overcome if a technical consultancy organization wishes to change strategy. Much of the knowledge needed to carry out the professional tasks is learned by socialization, and most of it is tacitly held in the brains of the employees.

5.1.3 Business processes

Based on internal manuals (included in J&W Företagssystem, KM Kvalitetssystem, SCC Kvalitetssystem, and VBB Viak Företagssystem) from the four consultancy companies in the 1997-98 study, a generic process model of how projects could or should have been initiated and managed is described here. The model primarily describes the business processes based on the formal process descriptions found in the quality assurance systems and on interviews with line managers, project managers and senior consultants at the four technical consultancy companies. When doing process mapping, activities have been assigned to activity owners, corresponding to functions such as “project manager”. Along with the business process mapping, sub-processes within the knowledge transfer process have been mapped and marked in the figures with a capital letter in a circle in order to refer to sub-processes in the model of knowledge transfer in technical consultancy organizations, as first presented in section 2.8. The five mapped knowledge transfer sub-processes were: (A) acquisition, (D) distribution, (M) making meaning, (O) organizational memory, and (R) retrieval. When mapping knowledge transfer sub-processes, the content of each business process activity was analysed and related to the prevalent knowledge transfer sub-

[22] The function of the consulting engineer can be compared with Maister’s grey hair category as well as the procedure category.

[23] This last function seems to belong to Maister’s procedure category.

process. It was usually easy to map knowledge transfer sub-processes. The many reviews were more difficult to map since they were complex and included more than one knowledge transfer sub-process. Reviewing business processes from a knowledge transfer process perspective also gave an opportunity to map features that are seldom or never in the knowledge management literature.

Generally the analysis of empirical data showed only small differences between the companies, and the major differences are indicated. It could very soon be seen from reading quality manuals and interview transcripts that the four companies had a shared view of the design and construction process. They saw it as starting with marketing activities, continuing with sales including tendering, and ending with project management[24].

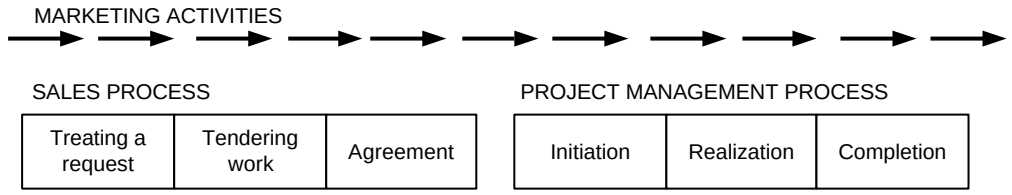

Figure 5.1 Business processes and their sub-processes in the four companies.

All four companies put special emphasis on the early stages and project start up. Although the design work is the core business of construction technical consultancy companies, it must be preceded and supported by marketing activities. Processes in technical consultancy organizations can be divided into those carried out within projects by the project organization and those carried out by the permanent organization to support the project organization.

Marketing activities

Marketing activities usually precede the sales process, although a sale may occur without the client being reached by marketing activities. Marketing activities are continuous in technical consultancy companies, and a client can be the object of marketing activities also during a project. All employees in the technical consultancy companies are expected to behave as good representatives for their companies. One company had sent all the employees on a business training course to help them think more in terms of the business: all possible business opportunities should be utilized. As these large companies have no partners and are quoted on the Stockholm stock

[24] The first two stages can be referred to as the pre-project stage as described in Cooper et al. (1998) or as client relations as described by Maister (1982). They are performed by the permanent organization in contrast to project management, which is performed by the temporary project organization starting in the pre-construction process and ending in the post-completion phase (Cooper et al., 1998). According to the terminology of Maister (1982) the project management phase includes two major processes: project management and performance of detailed professional tasks.

exchange, project managers and line managers also carry the responsibility for developing and maintaining long term client relationships. Line managers are usually responsible for organizing marketing, sales, and customer relations within their areas.

It is usual that each customer (client) of the technical consultancy company has an account manager, whose function is to develop a professional and social relationship to the customer and gain mutual trust and long-term confidence. By being attentive to these relationships, the consultants should be able to sell as much as possible from the corporate service portfolio as soon as an opportunity occurs, including services from other departments or divisions. All four line managers and all four project managers agreed in the interviews that customer knowledge is essential to transfer for use in contact situations, as well as knowledge about services produced by other departments and divisions. When this first investigation was performed in 1997-98, none of the companies had corporate customer databases to store customer knowledge or organized approaches to acquiring and distributing customer knowledge. Nor were such efforts observed in cases where the customers were large organizations with buildings, roads, or railways dispersed over wide geographical areas and therefore served by many local account managers from the consultant company. In some cases when an account manager knew that a customer had a business relationship with other units within the company, those units and project managers were contacted. Line managers, senior consultants and project managers all agreed that in order to be aware of multiple relationships, they had to rely on their personal contact networks, and read reference object lists and the internal information for the company regularly.

Knowledge about the market has traditionally been found through personal contact networks and by reading trade magazines such as “Aktuella arbeten”[25] (current work). But consultants in the areas of building design stress that it is already too late to get a project when it is presented in such magazines. In civil engineering areas such as roads and railways, much of the work is subject to the Public Procurement Act, implying that new projects must be announced and publicly tendered for. It had also become possible to subscribe to a review of projects from the EU database on public procurement published in TED (Tenders Electronic Daily). Other ways to be informed about the market the consultants mention include getting involved in associations and social activities, also studying investment plans and other public sources.

[25] Published by Byggfakta and also available at http://www2.byggfakta.se/. Byggfakta is since 1998 a subsidiary in the multinational CMD Group based in Atlanta, USA.

Within the studied consultancy companies, there are also different kinds of meetings where market information is transferred. Line managers at different levels have weekly meetings with subordinated line managers. At team or department level, there are often weekly meetings where resources, personnel, projects, and support are discussed. One of the companies has special market meetings with account managers, project managers and sub-project managers every second week. New and incoming projects, projects in progress, and completed projects are discussed and market activities planned, coordinated and monitored. Account managers are correspondingly supposed to keep their customers informed about service developments and changes in the company. This is usually done by visiting the customer, by telephone, letters, theme meetings, training, seminars, site visits and reading articles in the technical press, trade magazines and daily newspapers.

Account managers usually work actively with the marketing of their company to the client organizations. The twenty consultants interviewed who were account managers all stated that they got most of their new projects through their personal contact networks and recommendations from customers. One project usually generates continued confidence leading to continued or new projects[26]. However, personal contacts, reference objects and previous projects for the client still are crucial when it comes to the client's evaluation of many, well-qualified tenders in the sales process.

In their quality assurance system, one company lists selling factors. Those to the content were independently confirmed by the interviews with managers from all four companies when the "how to get involved in a project" theme was discussed. As selling factors, personal trust, previous assignments in combination with competence, interesting ideas and the client's confidence in tendering documents were mentioned as essential. To increase customer confidence and to simplify individual marketing efforts by employees, the companies continuously produce marketing materials such as reference lists, presentations, and brochures on completed projects. These companies also try to emphasize the importance of developing new ideas and solutions to problems. Such work may include finding possibilities for a customer before the customer knows about them. Contact networks not only include customer relations but also relations to other external actors such as municipal authorities, contractors, and building material suppliers. This is emphasized in the organizational business systems.

[26] There are differences here between various types of construction. Departments working with large construction projects such as motorways and railways usually have fewer customers than the building services engineering consultant. Almost all motorway and railway projects belong to clients from the public sector such as the Swedish National Road Administration (*Vägverket*), Swedish National Rail Administration (*Banverket*), and municipalities that have to pay attention to the special rules of public procurement.

The sales process

Marketing activities ought to lead to a sales process, aimed at producing an agreement and a contract between the technical consultancy company and the customer. Three of the four companies divided the sales process into three sub-processes:

1. Preparation, treating an incoming request or invitation for tender.
2. Tendering work and work with making a tender and a contract proposal.
3. Making an agreement and finishing the sales process.

There are no sharp lines of demarcation between sub-processes in the sales and tendering process. Instead, there are different governing decisions, which must be made to continue with the project. The first is whether or not it is worthwhile to submit a tender at all. Many circumstances affect such a decision (see Figure 5.2) and the decision is made by an authorized representative (*ombud*) at the technical consultancy company. Depending on risk and size of the project, the authorized representative may be anyone from the level of line manager up to the managing director. Usually the lowest line manager in the hierarchy (the team or department manager) acts as the authorized representative. However, most of the documentation used for making the decision are usually drawn up by the consultant who will be the project manager, or by the account manager.

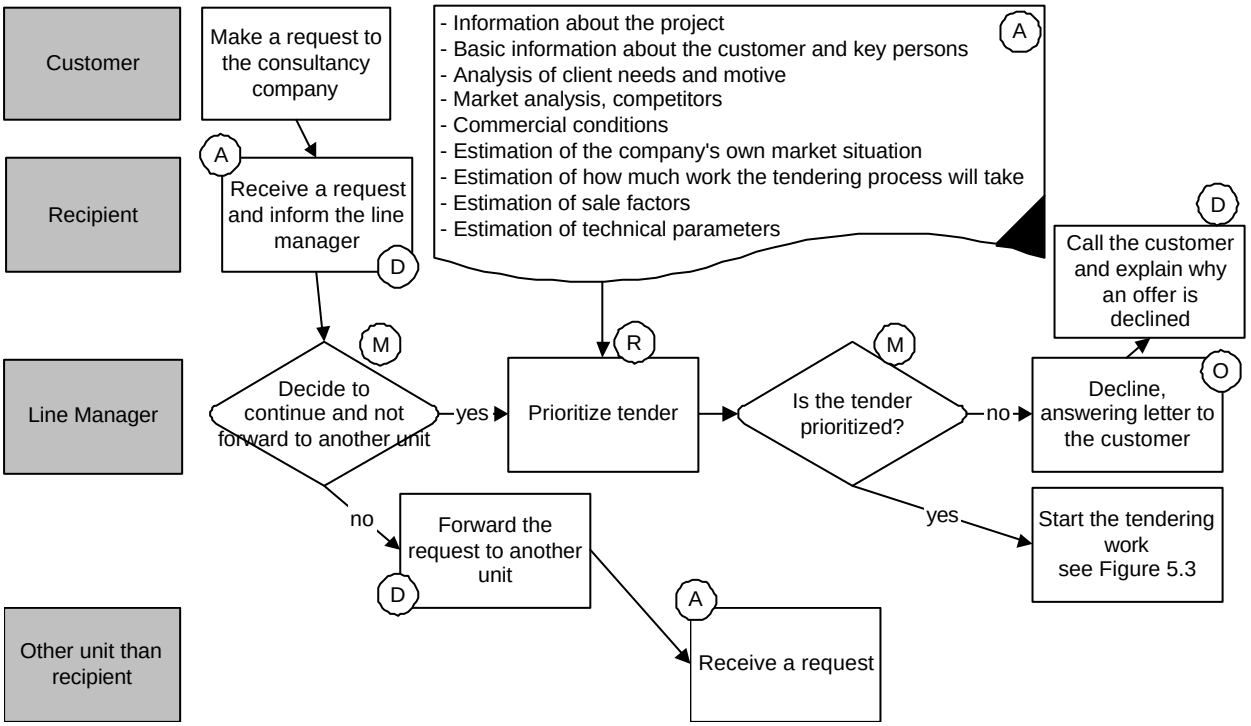

Figure 5.2 The sub-process of treating a request. Activity owners in grey boxes and prevailing sub-process in the knowledge transfer process in circle: (A) acquisition, (D) distribution, (M) making meaning, (O) organizational memory, and (R) retrieval.

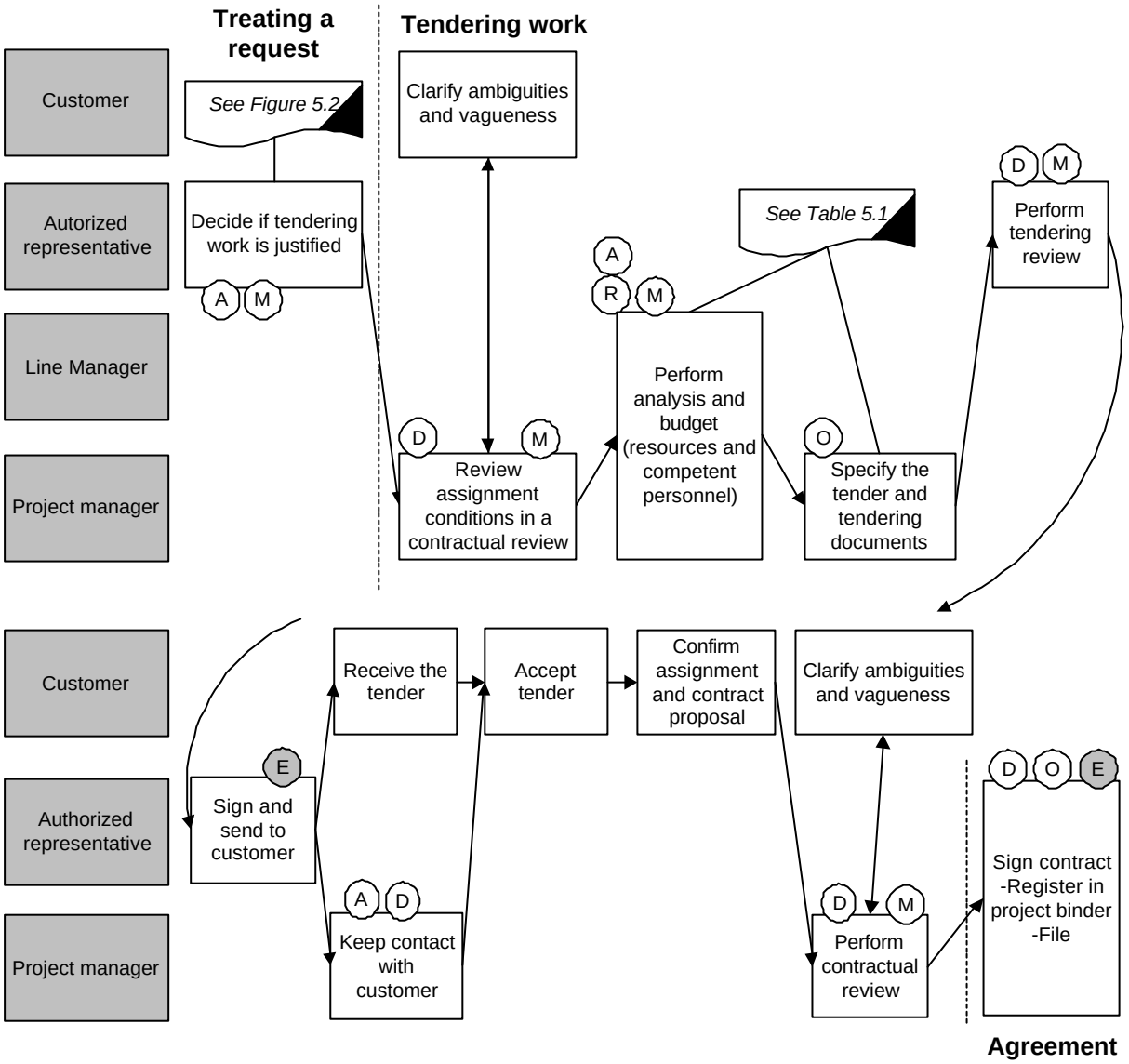

Figure 5.3 The three sub-processes within the sales process. Activity owners in grey boxes and prevailing knowledge transfer sub-processes in circles: (A) acquisition, (D) distribution, (M) making meaning, (O) organizational memory, and (R) retrieval. External transfer of knowledge and information from the consultant company is marked (E).

If it is decided to proceed with the contractual work it is time to assign a project manager unless this has already been done. The project manager is then supposed to review and check all documents for conflicting information and ambiguities and if such are found, solve the problems together with the customer (see Figure 5.3). The project manager also learns how the customer wants to have the tender presented. If the project is large, there will usually be a team of consultants that reviews the documents together. Such a contractual review is intended to ensure that the assignment is well understood by the consultants. It will also be decided by the line manager if the consultancy company has the necessary competence available to complete the project. The

customer is responsible for specifying the assignment in tendering documents when consultants are invited for tendering. Agreed assignments are made in consultation where the consultant and the customer together specify the scope of the assignment, level of details and documentation, budget, routines for customer claims, and format for delivery. In such reviews meaning is made by interpretation through dialogue, critical reflection and process checks as well as analysing information by rational analysis, problem solving and extrapolation from reference objects.

The project manager (in some companies called tendering manager during the sales process, *offertledare*) or the tendering team then draws up a tender under surveillance of the authorized representative. Any sub-consultants are invited, and an analysis and a cost estimate are made with time, resources, economy, quality, environment, communication, risk, procurement and deliverables taken into consideration (see Table 5.1). Much knowledge has to be acquired or retrieved to cover all aspects described in Table 5.1 in order to make the analysis, interpret the situation and make meaning of what should be designed. Personnel resources are usually discussed with the responsible line manager or a superior manager depending on project size and on involved teams or departments.

Table 5.1 Aspects needing clarification in tendering work.

Project management	**Scope of assignment**	**Time and resources**	**Financial matters**	**Quality**	**Environment**
-Management -Administrative routines -Routines and time for customer cooperation -Routines for customer changes and claims	-Description of activities -Limit to scope -Understanding of customer needs and requirements -Quantification of obligations such as meetings -Risks -Coordination responsibility -Conditions and norms -Product	-Total time -Delimitation in phases and stages -Times for customer decisions, directions, and specifications -Times for external parties decisions e.g. authorities -Time plan for delivery -Project time plan -Resource plan including personnel	-Costs -Risks -Production cost -Price per drawing in comparison with similar project and tendered price -Remuneration, payment conditions -Incentives and special compensation	-Customer quality plan -Preliminary quality plan -Reference projects	-Identification of environmental aspects of the project process as well as the product and how they are to be treated
Organization	**Communication**	**Risk analysis**	**Procurement**	**Deliverables**	**CAD**
-Organizational structure map	-Routines for how to communicate with the customer, internally as well as externally	-Responsibilities and reservations within high risk assignments	-Sub-consultants -Services from other departments in the technical consultancy company	-Describe which documents are to be included in the assignment -Specification of what to deliver, when, how, in what format and how many copies	-Technology -Versions -Coordination -Management of layers -File format

The tender is drawn up and reviewed by the authorized representative or by a special appointed reviewer. In some companies a sales consultant is responsible for assuring that the sales process is carried out according to sales policy and rules. This review is called the tendering review. The tendering document is then signed by the authorized representative and sent to the customer. This activity is the first time knowledge formally leaves the consultancy company, marked E for external transfer in Figure 5.3. Much information enters and leaves the organization but it may be difficult to verify whether the information is reliable. The activity of certifying information can only be carried out by an individual who is authorized to do so by the organization. Here, the authorized representative certifies the transfer status of the tender by signing it.

Then a waiting period follows until the customer responds. The consultants are encouraged to look after the interests of the company and stay in regular contact with the customer. The customer may return with a contract proposal. If such a proposal is not written, the consultant is expected, according to internal quality assurance systems, to return a written confirmation to the customer. In both cases, another contractual review will follow before the contracts are signed and the sales process is brought to an end. Finally, before completing the sales process, all documents and review protocols are registered and filed.

The project management process

As soon as a contract is signed, the project can begin. In three of the four companies, the project management process is generally divided into three sub-processes: initiation, realization, and completion. A variant with four sub-processes was found in one company: plan, produce, deliver, and close project. However, on the activity level, there was little difference between the four companies.

Initiation of a project

The aim of the sub-process *project initiation* is to plan for the realization of the project so that the product will be delivered according to what is agreed with the customer in the contract. At the project initiation, there will be fundamental administrative work that will be the foundation for quality assurance during the project. This administration work will principally consist of manning the project, putting people to work, and producing and registering quality related documents and binders that will be in use for the rest of the project.

At project initiation, a project manager has to be assigned to the project, if not earlier. At least there must be someone responsible for managing technology, costs and revenues, quality and work itself. The project manager and the

authorized representative review the project and the project manager finally takes over responsibility for the project. Usually a project announcement is made to supporting departments such as the finance department so they can create support for financial control and monitoring. If the project manager has not taken part in the sales process, a contractual review will follow. If anything is found to be unclear or ambiguous, the authorized representative and the customer are contacted. All details are clarified and another contractual review made. All contractual reviews are documented and archived according to the company quality assurance system (see Figure 5.4).

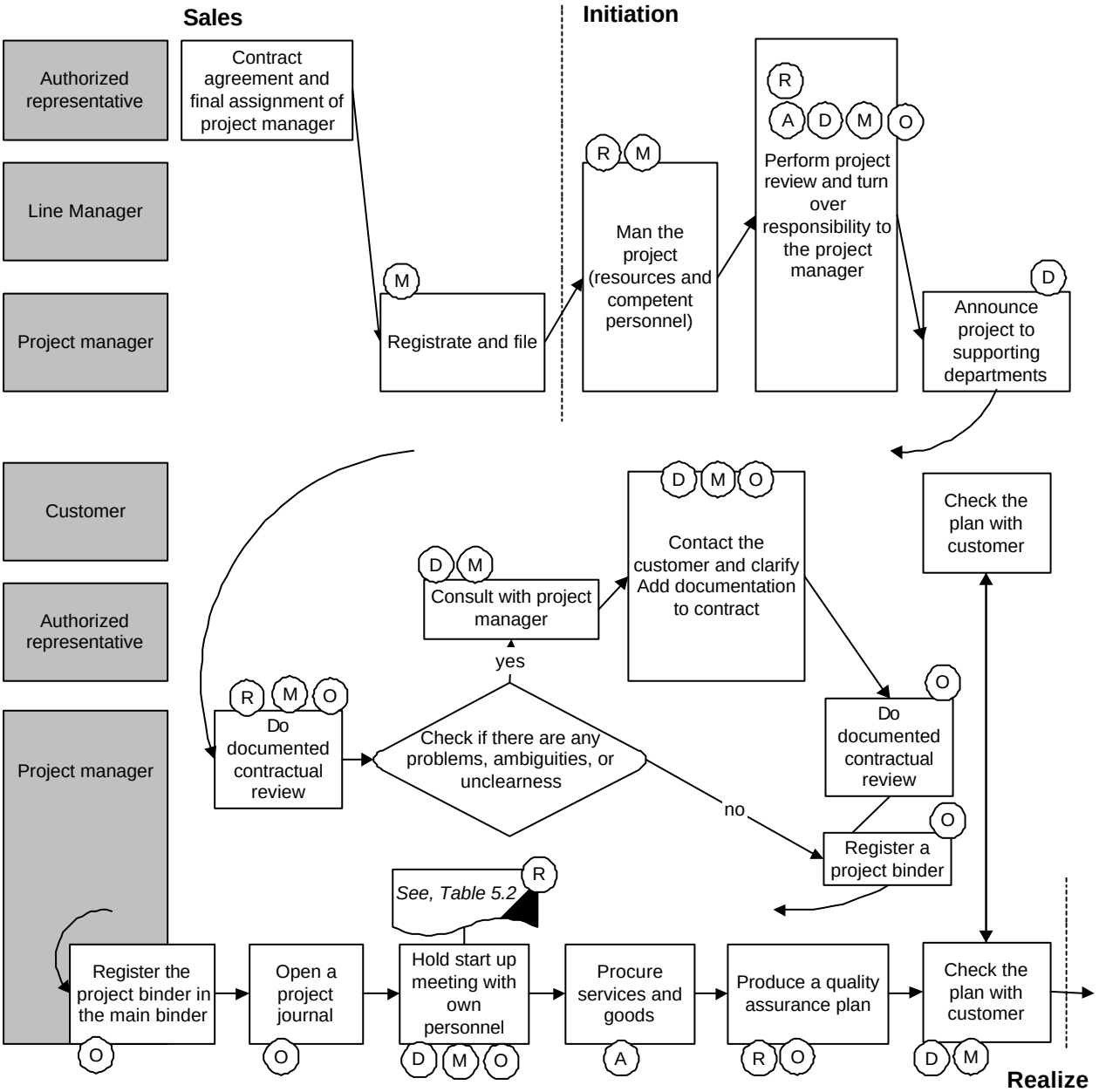

Figure 5.4 Initiation of a project. Activity owners in grey boxes and prevailing knowledge transfer sub-processes in circles: (A) acquisition, (D) distribution, (M) making meaning, (O) organizational memory, and (R) retrieval.

The project manager is responsible for having a project binder registered. All documents from the project (including documents from the sales process) are archived in that binder. Project binders can, as in one company, be registered in the main binder at the department. The main binder is a register for all project binders at the department. A project usually has more than one project binder and it is important to know how many there are and how they are identified so that documents do not disappear. As the project binder comes into existence, a file structure is created on a file server. A project log is also opened. Personnel are assigned to the project by the line manager in consultation with the project manager and other project managers at the department. The project manager then initiates a *start up meeting* (in some companies called an assignment review) with all personnel assigned to the project. The quality assurance systems have agendas for such meetings. Examples are presented in Table 5.2.

Table 5.2 Examples of agendas for the project start up meeting.

KM (KM, 1997)	SCC (SCC, 1995)	VBB Viak (VBB Viak 1997)
1. Project management	1. Assignment conditions	1. Assignment conditions
2. Scope	2. Limitation of scope	2. Assignment scope
3. Time and resources	3. Special requests from the client	3. Organization, client - consultant
4. Finances including budget, cash-flow plan, routines for changes and additional works	4. Organization, resources, responsibility and authority	4. Organizational and technical limits, responsibilities, and authority
5. Quality	5. Quality plan	5. Time and resource plans
6. Environment	6. Time plan	6. Economic limits/activity budget
7. Organization	7. Assignment budget	7. Requirements
8. Communication	8. Document, delivery	8. Document management including digital data and information
9. Risk analysis	9. Audits, check lists	9. Control plans and check lists
10. Procurement	10. Follow up, reporting	10. Applicable norms
11. Product (drawings and documents)		11. Authority contacts
		12. Risk analysis (review)

Before the start up meeting, the project manager has planned and prepared the assignment so that all documents needed for the discussion will be available. The start up meeting is also a second chance for the project manager to review the project, distribute information to the internal project team, form a shared vision, get feedback from the personnel and to see if anything has been forgotten.

Some companies classify projects according to project size to avoid using too much time for administration compared to the time it takes for regarding the project. One company used a typology of A, B, and C assignments where A are normal projects, B are short projects and C are client-driven projects in which the employees of the consultant company are seen as a client resource. Normal projects include all activities in the project management process. Shorter (B) projects minimize most activities and fulfil only the most frequently demanded activities. In shorter projects the project manager may be the only personnel resource, something that makes start up meetings,

detailed budgets and time plans superfluous. Documentation is usually less detailed in client-driven projects (type C). Another company has a simplified routine and process in their assignment manual, dedicated to smaller assignments. Observations on site indicate that project managers in the other two companies without a typology of projects defined usually adapt and simplify the norm in order to fit a variety of assignments.

There are two prevailing kinds of assignments: investigative assignments and detailed design assignments. Investigative assignments are usually vaguely defined. The project manager can therefore, to a large extent, control the project output. The customer might have defined a perceived problem but it may very well be just a symptom of the root cause. It is therefore common to start such assignments with interviews with the customer in order to find root causes and a basis for continuing the assignment. Detailed design work assignments are much more specified from the start. Specifications in previous phases make the assignments easier to define and plan. Some customers, especially professional customers, specify assignments in detail. Large public or publicly owned client organizations such as Akademiska Hus, Vasakronan, the Swedish National Rail Administration, and the Swedish National Road Administration often have standards of their own that also include standard solutions and standard components. They also have templates for how the process output (deliverables) should be presented. Such specific requirements and standardization of output also influence the subsequent process of project realization.

After the start up meeting, the procurement process starts. Sub-consultants, other services, information and goods are procured. Sub-consultants can be used to bring in specialist knowledge or they can contribute as extra resources. Resources from other departments might also be brought in. The project manager establishes a quality assurance plan adjusted to the assignment. If the assignment includes more than one consultant there will be a quality-planning meeting, where the quality assurance plan is drawn up. Quality assurance plans usually contain information about the scope, customer requirements, governing documents (such as contract, process descriptions, etc.), milestones, task assignments, descriptions of customer and consultant organizations, who is responsible and who has authority for doing what, how results are going to be audited, verified, validated and delivered. The quality assurance plan is then reviewed with the customer.

Sub-processes of realization and completion

The aim of the realization sub-process is to create and deliver the product in accordance with the agreed and expected terms. Assignment reviews are made continuously after the first start up meeting with the customer and other consultants involved, where the scope and special conditions are agreed (see

Figure 5.5). Continuous assignment reviews are a component in checking and verifying the work. This involves a comprehensive review of results and evaluation of whether the results fulfil specified requirements. Potential problems are identified and alternative solutions evaluated. Assignment reviews are also made together with the sub-consultants. In some projects, planning meetings are held with other consultants, the general consultant (if the assignment places the company in the position as a sub-consultant) and the customer. All meetings are recorded in chronological order in the project binder.

The forms for communication established at the start up meeting can be improved at planning meetings. Observations in the four companies shows that it is usual for the project manager to do an internal and informal check each day that anything is done on the project. The project manager meets all staff involved or just the relevant engineer to see what has to be done and what has been achieved. Measures, decisions, visits at site, analysis and consequences are discussed. Sometimes new tasks are assigned to the project team and distributed among the team members. The project manager gives instructions or guidelines of how the work is to proceed depending on how experienced the team is.

The document catalogue is continuously updated. Project managers usually meet once a week with the line manager to inform about resource needs. This is usually combined with the weekly or biweekly planning meetings with all personnel in the department or on the team. Such planning meetings make it easier for the line manager to keep all consultants assigned to projects.

Changed conditions and the need to make extra work or changes are discussed with the customer as soon as possible. Such discussions are documented and signed in order to certify the correctness of information that has been externally acquired from the customer. The project manager then informs the project team as soon as possible. The authorized representative and the line manager are continuously briefed about advances in the project work. Special reviews are held with the authorized representative or the line manager as each new phase start or if there are changes that will lead to an assignment review and renewed planning. There can also be a need to bring in more people or to report about completion. All consultants perform their own quality self-checks and audits to make it easier for the project manager to verify and transfer the information to the authorized representative, who certifies its reliability and validity to the customer. The signing of drawings and documents by the consultant and the project manager is part of that process. It must be noted that the 31 interviews show that not all consultants were familiar with how the formal self-checks should be performed and that a vast minority of them thought that there was little emphasis on the

verification of results. According to the interviews with line managers, senior consultants and project managers, not all project managers or authorized representatives give priority to detailed reviews of the work performed by consulting engineers and assistant consultant engineers.

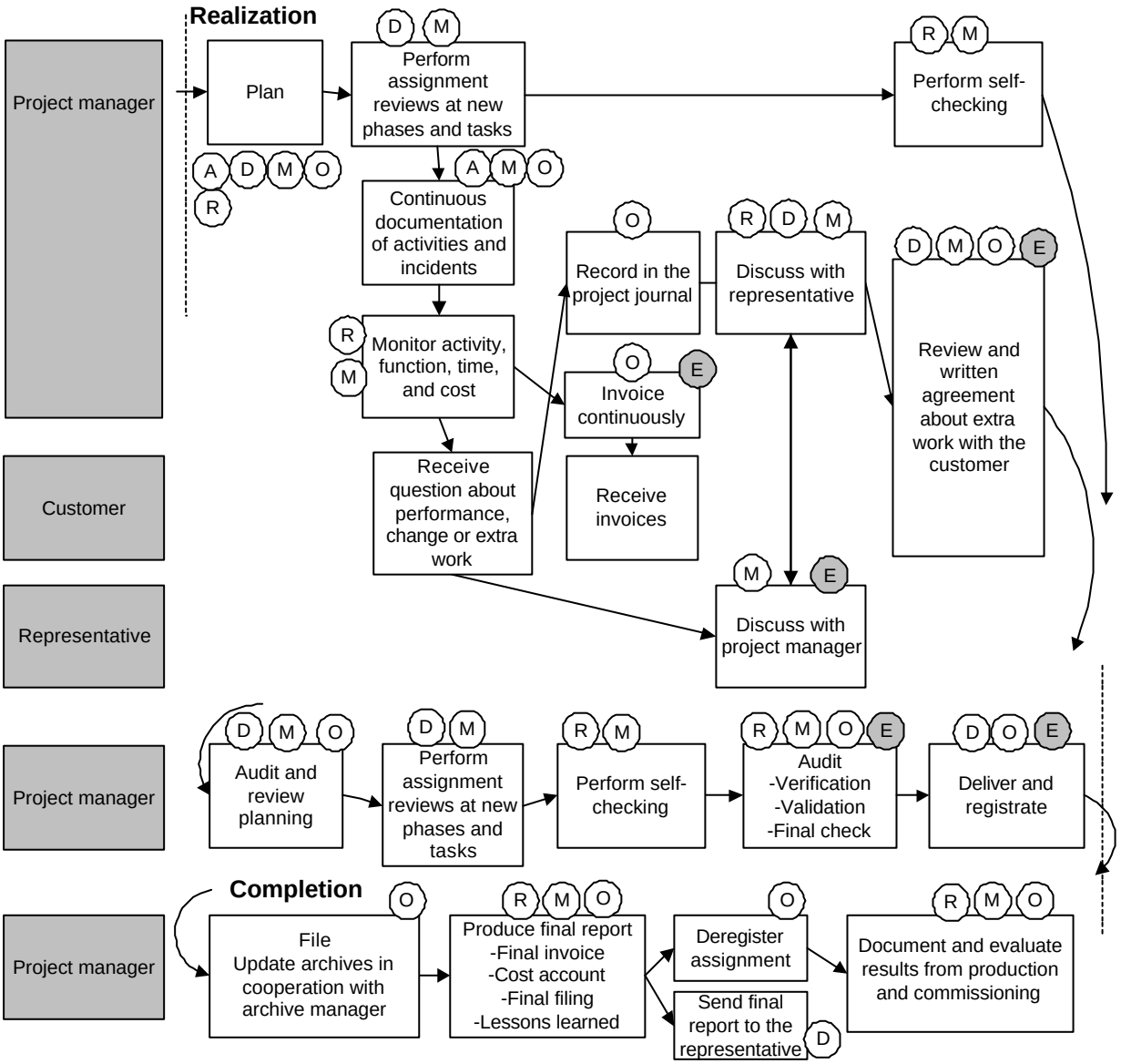

Figure 5.5 Realization and completion of a project. Activity owners in grey boxes and prevailing knowledge transfer sub-processes in circles: (A) acquisition, (D) distribution, (M) making meaning, (O) organizational memory, and (R) retrieval. External transfer of knowledge and information from the consultant company is showed with an E in a circle.

The hierarchy of formal functions is mirrored in the actual distribution of activities assuring and certifying the quality, validity and reliability of transferred information and knowledge. This pattern appears to be closely connected to the phenomenon of slow careers, why it takes so long to become a project manager in technical consultancy companies as compared

with becoming a manager in a manufacturing company that uses other methods, such as a thoroughgoing standardization of the process and the output to assure quality.

Decision-making and planning that concerns more than one company in the project organization, are mainly carried out during design meetings. The needs for coordination and information transfer are identified for the first time at the project start up meeting. Coordination can be achieved through coordination meetings with fixed agendas, or by exchange of CAD files, by plotting information from different specializations on the same drawing, creating a shared CAD model on the same project computer server, and by securing a unique distribution list for auditing others documents.

Informal coordination meetings supplement formal coordination, especially in tasks that require multidisciplinary design efforts where clashes of geometry or schedules are likely. The electrical engineers usually meet building service engineers early in the project to discuss canalization, shafts and the space above false ceilings. The geotechnical engineer and the highway civil engineer can meet to discuss horizontal and vertical alignment and stability. Later, a consultant can also be contacted and asked to visit the construction site for construction meetings, to solve problems on site, to explain a difficult set of activities before it begins, or to answer general questions. In addition to face-to-face contacts, the interviews indicated that telephone or fax were considered to be the other most important media for communicating with external project members. E-mail began acquiring more importance during this first study (1997-98) but it was still said in the interviews that the usual procedure was to exchange floppy disks with CAD files[27].

Realization of an assignment ends with delivery. Before delivery, the results must be approved be verification, validation and final checking. Verification implies that results are secured according to the internal specifications. Validation implies that results will be checked relative to customer requirements as specified in the contract or other documents so that customer needs will be satisfied. The final check ensures that all other checks and reviews are done according to the quality assurance system and that any claims have been taken care of. All kind of checks, reviews and audits are documented. The final approval before delivery is usually done by a department manager or another superior line manager. Delivery can then take place according to a delivery plan agreed with the customer. At delivery,

[27] It must, however, be mentioned that during the study developments were rapid on the IT front in the four companies. All consultants got an e-mail address and access to the Internet through ISDN connections or LAN with fixed connections. General management systems including the quality assurance systems were now being published on intranets.

sender, recipient, mailing list, date, aim and scope are documented. Delivery is registered in the assignment binder.

The last sub-process in the project management process is completion. The aim of closing the files or completing the project is to end the assignment financially and administratively. The project manager is responsible for completing the project and closing the files as soon as all obligations to the customer have been carried out (see Figure 5.5 and 5.6). All financial transactions must have been completed. The project manager decides what should be filed and the assignment binders are prepared. The directory of files, if it exists, is updated in cooperation with the archive manager and assignment numbers are closed. The project manager finalizes cost accounts and holds “lessons learned” meetings with all personnel who have contributed to the project and with the customer. Technical, financial, as well as organizational issues are put on the agenda. A final report is written by the project manager and given to the authorized representative. The project can then be deregistered in the main binder and the project database is closed.

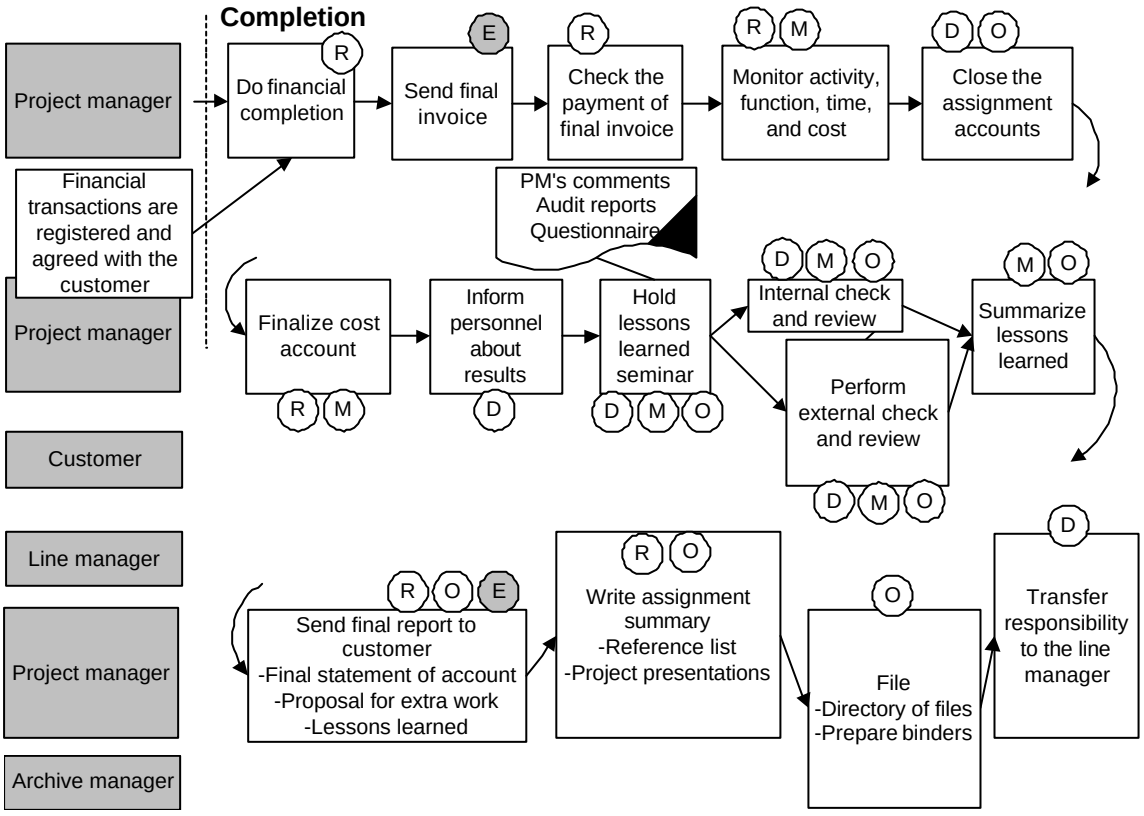

Figure 5.6 Detailed process map of completion. Activity owners in grey boxes and prevailing knowledge transfer sub-processes in circles: (A) acquisition, (D) distribution, (M) making meaning, (O) organizational memory, and (R) retrieval. External transfer of knowledge and information from the consultant company is showed with an E in a circle.

The project is followed up and evaluated throughout construction until the guarantee inspection is done. Project binders are usually kept available for additional protocols from construction, commissioning, final and guarantee inspections, and also for comments from the customer during this period of time. Extraordinary and new kinds of assignments are more carefully documented. A basic description for various reference lists is made. The project can then be finally added to the reference list.

Knowledge transfer in the business processes

The most frequently recurring sub-process in the knowledge transfer process when assigned to activities in the business processes described above was making meaning (see Table 5.3). It was followed by organizational memory, and distribution of information and knowledge. Acquisition was the least frequent sub-process identified in the business process maps, but this should be interpreted as a consequence of that this is the only sub-process where knowledge crosses organizational boundaries at the input side. At the output side, when knowledge crosses organizational boundaries, there are routines to certify information and knowledge transferred. Having a specially designated employee sign the output is such a procedure. It is interesting to note that procedures for certifying input are weaker.

Table 5.3 The number of knowledge transfer sub-processes mapped to the five process maps of business processes.

Business process map	Figure	Knowledge transfer sub-process				
		A	D	M	O	R
1. Treating a request	5.3	2	3	2	1	1
2. Sales process	5.3	3	5	5	2	1
3. Initiation of project	5.4	2	6	8	9	5
4. Realization and completion of project	5.5	2	8	12	9	6
5. Detail of Completion	5.6	0	6	6	8	6
Total		9	28	33	29	19

Knowledge transfer sub-processes: (A) Acquisition, (D) Distribution, (M) Making meaning, (O) Organizational memory, and (R) Retrieval. The number of knowledge transfer sub-processes in process map 4 has been reduced with corresponding sub-processes in process map 5.

Routines for certifying the validity and reliability of information and knowledge when these cross the boundary between organizations appear to be a field for new strategies. It is difficult to choose an information technology support strategy without deciding how data, information and knowledge should enter and leave the organization. When the four companies started to use CAD systems they had to develop new systems to manage multiple versions of CAD files as well as several versions of the software. Not only financial consequences for changing systems has to be analysed before strategies are changed, but also consequences for intellectual property rights and ownership of knowledge that has been acquired and created during assignments.

5.2 The second study, 2000

This section describes the present (spring 2000) situation of knowledge management related initiatives in the four technical consultancy companies. Interviews with managers on the executive level and department managers indicate that business processes were basically unchanged since 1997-98[28]. Neither has any revolutionary new process support tool, such as a workflow system, been introduced since the first study and therefore there is no reason to believe that the consultants have changed their principal way of working in projects as it was described in the previous section. However, enabling conditions and facilitating activities for transferring knowledge and information have changed, both when it comes to how the companies and departments are organized and the technological support. Based on interviews carried out in early 2000 with managers at executive level as well as at department level (see section 4.7.1) this presentation is structured according to the enabling conditions and facilitating activities discussed in section 2.7. The primary focus is on establishing the differences and similarities between the companies and describing them in a knowledge transfer related context. This section also aims to give a background for further interpretation and analysis of the two questionnaire surveys to be presented in chapters 6 and 7.

5.2.1 Organizational enablers and facilitators for learning and knowledge transfer

The discussion of organizational enablers and facilitators for learning and knowledge transfer is structured in the following five sections: organizational structure, communication and the monitoring of strategy, process, culture, and systems for training and learning.

Organizational structure

All four consultant groups are organized differently. However, in terms of organizational structure, there are two principles for organizing technical consultancy groups, and it is said that the groups oscillate between the two principles. The first is geographical organization and second is technology organization by specializations such as structural mechanics, railway engineering and building services. Moreover, during the last four years, two of the groups have merged all their Swedish operations into coherent companies. This is said to have been done in order to reduce transaction costs, make it easier to cooperate and better provide knowledge and services from all specializations than when being a group of separate companies.

[28] The business context and its change is described in a wider perspective in Chapter 1.

One of these two groups was transformed from a geographical organization into a technology organization in 1998. Middle management was reduced during this reorganization, which was intended to focus on technical excellence and facilitate knowledge transfer between the technical specializations. This group is now consolidating its operations after having offered all employees aged 62 or more early retirement and after having closed all unprofitable offices. The other group reorganized in 1998 according regions. This geographical organization was said to have been introduced in order to facilitate cooperation among the specializations in local markets. Conflicts among specializations about tender strategies would no longer rise to the top executive level, but could be solved by middle management regionally. However, as the regions became stronger entities, almost all technical development at national level ceased. This group is now trying out new ways to cooperate at company and group levels.

The other two groups have organized their various specializations within separate companies. One of the two groups has organized its subsidiaries in regions. The three departments studied in one of their regions have recently reorganized into two specialist departments mainly doing investigations and feasibility studies and one department mostly doing detailed design.

The company studied in the fourth and last consultancy group has a mixture of a geographical and a technology organization. Two of the three departments studied are organized into three geographical regions. One of the departments is organized as a technology organization at the national level. Because all three departments work together on many assignments, local strategic issues will be solved at the top executive level in the company if department managers disagree.

The structure of any consultancy organization seems to be crucial to determining what kind of knowledge is transferred. On the one hand, a technology organization seems to be good at transferring technical knowledge. It is also easier for such an organization to standardize its infrastructure, such as its IT platform for engineering tools. On the other hand, knowledge about other technical specializations and customers seems to be more difficult to transfer in a technology organization than it is in a geographical organization where the specializations are more closely organized. No formal attempts were made to make particular knowledge holders such as specialists in the companies accessible to their colleagues. They work full time with projects at their departments and usually answer questions from other consultants in the company, but if it would take considerable time to answer a question, they would have to be assigned to the project.

Communication and the monitoring of strategy

In section 2.7.1 strategy and knowledge were discussed. Clarity of vision and language were said to be necessary for maintaining the knowledge base in a long-term perspective. How, then, is knowledge related to the overall strategies in the companies? When functional managers at the top corporate level were asked, they said that there is an intention and a strategy for facilitating knowledge management. However, those intentions were not familiar to all line managers at department level, with the exception of training. Although top managers stated that knowledge was related to the strategy of each respective company, such relations were often formulated in print more or less precisely as training, education, and leadership development (J&W, 2000a), "the overall strategy is to cultivate entrepreneurship and knowledge management" (KM, 2000, p. 9), development of human and structural capital (SCC, 2000), and "to build a true knowledge company in which knowledge in structured form is made accessible to all employees" (SWECO, 2000, p. 7). However, these published strategies were not well known and operationalized to explicitly express a system of knowledge management initiatives to more than one of the four responding managers at department level. In one company various market segments were discussed in relation to what kind of knowledge they provided. Similar to the strategies for technical consultants discussed in section 2.2.2, respondents in one company asserted that they focus on complex facilities with new solutions to new problems, and that they thereby try to avoid contracts awarded on the base of lowest price instead of knowledge and competence. Three of the four companies has knowledge management in its business concept. In the beginning of 2000, one of these companies summoned a meeting with all line managers and discussed the business concept, the vision, basic concepts and the language of knowledge. In this company, the line manager interviewed was clear about how knowledge management should be enabled and facilitated. Still, no measurements or monetary links to business value existed.

How is clarity of vision and language attained? All four companies have started to build up a common internal language related to knowledge management. Classification of explicit knowledge and experience from projects is mentioned as prioritized. Various initiatives can be found on the intranets but what seems to be difficult is to agree on a structure and classification that will be easy to understand for all employees. One company has appointed its technical experts to a committee intended to create a knowledge classification scheme and classify recently acquired explicit knowledge based on this scheme.

Another issue about the "communication and the monitoring of strategy" type of enablers and facilitators is knowledge responsibility and leadership. In

the interviews, it was difficult to determine who is responsible for knowledge management in these four companies. In one company the personnel manager is said to be responsible for competence development, but that is a minor part of knowledge management. In another company the IT manager sets goals for technological enablers and the local units are then responsible for developing their specific systems. There were some common systems such as the intranet and a basic software platform that figured in all four companies. The department manager in the third company believed that knowledge management issues come to the person who is responsible for new technology development within the organization, but he was not sure. In the fourth company, things seemed even more unclear, but knowledge management issues were said to be at the top of the executive agenda. Knowledge management is included in the mission of the fourth corporate group and a separate company has been created to lead the development and disseminate knowledge management solutions to the other companies in the group. However, from what was seen and heard in the interviews, this knowledge management solution includes only technological enablers so far. Knowledge management leadership and responsibility can therefore be said to have been fuzzy in all four studied companies.

Although knowledge management leadership and responsibility seem to be unclear at corporate level, it may be better at local level. What efforts have been made to develop local leaders into better knowledge managers and professionals? Many general management development efforts affect the management of knowledge indirectly. One of the companies has appointed a young (34-years-old) manager for one of their business areas. The intention is that he will act as an intermediary in transferring the ideas of the younger employees to other top executives. Another company practises what they call value-based leadership. All consultants at that company are responsible for their competence development and their contribution to the development of their team and the company. The department manager stated that all consultants should keep themselves worth hiring. This can be seen as an attempt to reduce the responsibility of management, but it also increases the freedom of the employees. To follow up progress, this department manager has yearly performance appraisal discussions with his employees, similarly to department managers at the other three companies. At one of the other companies, managers worked more as team builders or coaches, and career paths have been made clearer. One department manager at the fourth company makes use of Porter analysis to find strengths and weaknesses at the department level. Those strengths and weaknesses are identified through employee self-evaluation. Monitoring, done by management, identifies potential knowledge gaps that have to be filled with new knowledge. As a part of leadership development, all four companies have training programs for

their managers and potential managers. One company has a program developed in cooperation with the Swedish Institute of Management (IFL) and another company cooperates with the Stockholm School of Economics.

The department managers interviewed at each company were asked to give their opinions about what characterizes a good manager in a technical consultancy company. The first respondent said that the manager should help and support the employees. A manager must act exemplarily, build networks, communicate and visualize how all employees can contribute to fulfilling the goals of the company. Presence was also said to be important. The second respondent saw the manager as a coach with a mission to support the employees. This support should include talking with the employees, discussing which projects the department should start and follow up so that all employees have enough to spend on their projects. The third respondent focused more on communication and said that in order to promote creativity, managers must let the employees think by themselves before they are given instructions. The fourth respondent asserted that more managerial effort needs be put into human resources and into construction technology, and less than traditionally into financial issues.

It is thus obvious that all four companies have started to think in terms of managing knowledge, although this is not yet expressed clearly in visions and goals that are easy to operationalize. Responsibility issues for knowledge management had not yet been settled in any of the companies, but general leadership issues evidently now included the transfer of knowledge. All interviewed department managers saw their leadership more as being to support the employees and to build teams than to exert control.

Process

Applying a process perspective to knowledge transfer is aimed at making knowledge available to all employees in the organization. Today, much of the intentional efforts related to process thinking build on making tacit knowledge explicit. Explicit knowledge, knowledge erosion, experience, best practice and exposure to external variation and new knowledge are to be discussed in this section.

The first issue is explicit knowledge. Three of the companies intentionally collect explicit knowledge about administrative processes, quality assurance and CAD in databases. In the fourth company it is believed by the respondents that knowing who knows within the company is more useful. The department manager stated that it was too much knowledge that was not expressed in the documented output. Most knowledge about the process of solving the problem was stored in the brains of the consultants that did the project. Knowledge maps are said to be helpful. Nevertheless, the only

knowledge maps that were used in spring 2000 were the informal contact network of the employees and to some extent the CV (Curriculum Vitae) databases.

Although respondents in all four companies were afraid that knowledge would leave the company they did not believe that the second issue, knowledge erosion was a problem. Employees stay for a long time in technical consultancy companies and it was a common opinion among the respondents that retirement does not imply a risk of losing crucial knowledge, that there are other consultants who know the same things as those who are retiring. Only one of the companies works proactively with a program where older consultants hand over their business contacts to younger colleagues. Knowledge is said to have an expiry date. With a few exceptions, employees who retire are seen possessing knowledge that has passed that date and that old consultants are not willing to learn so many new things during their last active years.

The third issue is experience. Most of what is learned in projects is said to be tacit knowledge. To be able to work alone in projects and manage projects, experience of working as an apprentice for 5-10 years is assumed to be necessary. During this time the basic technical skills are developed as well as a contact network, used for finding knowledge as well as for business contacts. There are six examples of methods for acquiring knowledge and making it explicit that have been mentioned in the interviews. First, it is possible for the design team to visit the site, see and talk to construction workers, management and the client. However, such site visits are not usually made more than once or twice in each project, somewhat more often by the project manager. As the visits are short there is little time for going into details and deep discussions of how things work. Instead, as the second method, attempts are made by all companies to have a review with the client after the project is finished. Such a review can also include the contractor. Internal past project reviews are prescribed in the quality assurance system of each company. However, by the time the project is closed all consultants are already working with new projects and do not feel that they have time for such meetings. Instead the past project review and lessons learned seminar tend to treat primarily financial issues. Technical issues, if they are dealt with at all, are said to be treated very briefly and not systematically. Third, a wealth of documents are generated in the projects and documents that are perceived as having a future use can be included in registers of templates. Fourth, at least two of the companies have specialized consultants acting as a consultant responsible for

monitoring the development of a particular technology[29] and distribute information to other consultants with the same specialization. Fifth, one company use “super-users”, experts on methods and software who continuously evaluate new methods and tools. Sixth and last of the methods for acquiring and making knowledge explicit is the project report, usually containing more finance than technology and templates for further use.

The fourth issue is best practice. None of the surveyed companies has a set of formal best practices. There are some best practices at company level but they mainly include what has been identified as good reference objects. It seems that all four companies have tried various manual methods of collecting best practices in books and loose-leaf systems for technical tips but that it took too much time and money to find, collect and distribute these practices. At least three of the companies have failed to use best practices. One example was a database for designs that were supposed to be reused. Everybody involved thought it was a good idea as the project started, but soon, they found it difficult and time consuming to contribute to the database. It seems to be a general opinion among the interviewed department managers that such systems could be good in a web-based environment, but that personnel are still needed to maintain them. The non-conformity reports from the quality assurance system do not generate many proposals for making the process more efficient. Instead of standardizing processes the construction industry is well known for standardizing output. Norms and practices as discussed in section 2.2.3 can be considered as large knowledge bases to build on.

Exposure to external variation can help consultants to be more creative and to acquire knowledge. Traditionally, such external variation has been achieved by participating in more than one project and for each project working in different teams. Recently, the Internet has become a useful supplement to external variation, but the respondents still find it difficult to search for and find the latest, most relevant knowledge there.

Culture

A knowledge oriented culture was said (in section 2.7.1) to be distinguished by openness, multiple channels for information and knowledge and also on an experimental mindset. Rewards and motivation were said to be necessary ingredients for achieving a knowledge oriented culture. When people and structures are too familiar it may also be necessary to redesign the environment to change the present culture.

[29] Many consultants in the four companies have been assigned the part time task of expert gatekeeper for a particular field of technology (*teknikområdesansvarig*). Such gatekeeper functions are found on more than one organizational level with team gatekeepers and department gatekeepers, and there is a corresponding structure for meetings between experts.

How are openness, multiple channels and experimental mindset reflected in the interviews? Each of the four companies believes it is characterized by openness and that all employees who need particular information or knowledge about a project can have it. The organizational culture is perceived to be informal by the managers who were interviewed, and it is easy to meet and talk to colleagues in the corridor. What is more difficult is to meet colleagues from other offices, since individual consultants usually work in one and the same department. Two IT experts spontaneously said that the intranet is based on open communication. The reorganization of the Swedish operations in two of the groups into one company, as described above, also increases openness among employees. Other arrangements to increase openness include arranging meetings and social activities where employees get to know each other and begin to exchange knowledge. Formal meetings for managers from all levels in the company are used by one of the companies. However, knowledge and information from projects are mainly stored in project servers and in the brains of the consultants. Thus it is possible in all four companies to know that a project exists but to find that the project server is only open to employees at the department that did the job. Other employees can only gain access to that specific project after asking permission and after IT staff have allowed them access. Full text searches in project documents from the whole company or the division are not yet possible. When respondents assert that their companies are characterized by openness, it cannot be interpreted as instant access to project information across departments.

In the interviews with the four companies, little indicated that any measures were taken to promote an experimental mindset, at least not in two of the companies. In one company, a department manager said that he tried to make time for the younger consultants to think and develop their ideas before he gave them advice on how to solve a problem. The solution could then be a mix of new ideas and old well-established methods. Another company has tried idea seminars at the end of the day. Those seminars ebbed out after a few times, as people wanted to go home after work. Other small local knowledge management initiatives such as collecting all final reports from a department or specialization at an open area on a complete server or collecting good problem solutions in a large word document, have also been tried with varying results. It was thought that small, local and inexpensive initiatives should give fast results and be easier to implement. Lack of time was said to be the main obstacle to succeeding with such initiatives. Idea and suggestion boxes were also tried but the initiatives ended after just a few contributions.

Meetings represent an important subset of multiple channels available for knowledge and information transfer. Four types of meetings have been

identified through the interviews. First, all departments studied in the four companies hold meetings for their employees once a week or every second week. At such meetings finance, personnel, projects and planning are discussed. Second, building materiel suppliers or manufacturers come to coffee breaks and hold information sessions about new products, software or other tools. With the exception of the building services engineering department, this usually occurs once a month. At the building services engineering department suppliers would come for short (15-20 minutes) meetings twice a week. Third, the various technical specializations arrange annual seminars in three of the four companies. It also seems to be common that individual employees participate in those seminars every second year, half the consultancy company one year and the other half the next year. Fourth, technical experts meet a few times every year and discuss new technology and experience from projects. Notes are taken and notes from their discussions are also published on the intranet. Between the meetings, experts follow what is new in their respective areas at the same time as they work with their ordinary assignments. There are also channels with a longer period of interaction than what is typical for meetings. Borrowing consultants from other offices to balance the workload is quite rare. Department managers in three of the companies said that distance work in the sense of not moving to the office where the project belongs is usually seen as an inferior solution. The distance worker not only loses the socialization effect but also misses what is said at the coffee table. When borrowed consultants have worked out well, they have changed office for a brief period. Furthermore, job rotation in technical consultancy companies mainly occurs within the trainee programs for new employees who are recent graduates. Some other channels were observed, intended at building up personal networks. Mentorship is aimed at younger employees, but a formal program was active only in one company, where it had a slow start during 1999-2000. Moreover, there is training. As found in the 1997-98 study, there are many training programs, but the budget usually limits the number of days to approximately 2-5 per year for each employee. Technical consultants cannot therefore be said to have a strong training culture giving frequent opportunities to meet colleagues. Nor do they tend to have many internal seminars, technology meetings or exchanges of employees between departments. Instead the weekly meeting with the department seems to be the dominant channel for transferring information and knowledge, in addition to informal meetings such as coffee breaks and talking in the corridor.

Turning to rewards and motivation, there are no formal individual rewards for transferring knowledge in the four companies. There is, for example, no rewards for contribute to technical inquiries, databases or helping colleagues. Neither are there any rewards for reuse of solutions generated in previous

projects. One exception was a SEK 25 lottery ticket for contributing an improvement report. To motivate their employees, the companies try to send them to the courses and seminars they want to attend, encourage senior employees to become widely known as experts and younger consultants to work for promotion to consultant, sub-project manager or project manager. Goals for the individual are discussed at the yearly performance appraisal. One company has a method that focuses on three goals. They also have had an external promotional campaign where individual employees are advertised as the heroes of the company. The target groups for this campaign were both the employees and external business partners. The heroes were intended to embody ideals in the organization and a part of the corporate culture.

Finally, what about redesigning the environment? All four companies talk about rejuvenation and about recruiting young people, preferably with university degrees. Rejuvenation is also an issue within the area of business contacts. Older consultants are supposed to hand over their customer knowledge and business contacts to younger ones before their counterparts retire and are replaced by younger people. An anecdotal example came from a region manager at one of the companies. One engineer was proud of his many business contacts. He did not want to turn them over to his younger colleagues when he was in his fifties, but as he reached sixty most of his contacts retired and were replaced by much younger people. He had problems approaching them and building new relationships. They preferred to do business with younger people at other companies so the old consultant had problems finding work to do the last few years before retirement. Instead of being a contributor he became more of a waster, it was thought.

Another way of redesigning the environment is to strengthen the links to customers. Following the general trend in business, the technical consultancy companies have made various attempts to increase employee awareness of their customers. Changes in organizational structure is one mechanism that has been mentioned but other measures include training programmes and seminars with customers present. In one of the companies all managers were invited for what seemed to be just another internal seminar. When they arrived they were confronted with representatives from their largest customers.

Systems for training and learning

In section 2.7.1 it was assumed that feedback is crucial to learning. As previously mentioned few measurements of learning and knowledge transfer can be found in use in the four companies. The only quantitative indicator that described transfer was in use in one company, and was also mentioned in an interview as possible in a second company. It was the number of fulfilled

goals from the performance appraisals, so that lack of skills, knowledge, and motivation can be measured and compared with previous appraisals. This set of metrics was so new, however, that the line manager had not evaluated it yet. When it comes to training, all companies have what they call schools where they train their employees in several programs. Two of the companies use web-based training. Most web-based training programs concern software but there is also training available in soft skills such as holding a performance appraisal.

Another human resource management issue regards learning that occurs in teams. The composition of project teams has been discussed previously in this chapter and all four companies appear to have basically the same methods for composing their teams. Old teams where the team members know each other and have a shared language and common experiences can get to work on a new project much faster than a new team. Nevertheless, line managers try to alternate the participation of various experts in various teams so that many other consultants will learn from them. Team-learning also occurs together with participants from other companies in the project organization comprising all companies involved in the project.

5.2.2 Technological enablers for learning and knowledge transfer

In this section various IT tools are discussed in relation to their functions as enablers for learning and knowledge transfer. It is structured according to the four categories of technological enablers presented in section 2.7.2.

Knowledge transfer tools

A range of technical tools enable the flow of knowledge. According to the interviews, among the most common are telephones, facsimiles, e-mail, standardized hardware in combination with software, intranets, the Internet, groupware, telephone conferences, web conferences (using an intranet as well as Internet) and video conferences. Not all of these are used by all the consultants and the variation in use is also large, an impression that will be confirmed by the questionnaire responses to be analysed in Chapter 7. When the consultant transfers knowledge to external parties, the same combination of tools cannot be expected to be used as when knowledge is transferred internally. A contractor on site seldom has the same technical possibilities to send and receive information as in the office.

Virtual meetings are a comparatively new phenomenon for technical consultants, at least in practice. There is of course a long tradition of using telephone and facsimile. More recently the combination of e-mail (also for distributing CAD files) and telephone has become more frequent when

communicating with external project members. Net-meetings, virtual chat rooms, transparent capture enablers and visualization tools are not yet used. In two of the companies there have been local attempts to use video-conferencing and web-conferencing, but these have not been successful enough to arouse curiosity and to create a demand for diffusion to units outside the pilot projects. Discussion groups have been tried internally but the discussions have died out. In one company the discussion group deteriorated into a medium for expressing employee dissatisfaction. External discussion groups and mailing lists have been tried by some consultants, usually when doing investigations and feasibility studies and for special and unusual assignments. Two of the interviewed department managers had unsubscribed from the mailing lists soon after their assignments were completed, in order to avoid receiving too many e-mail messages in the future.

The Internet is perceived as a knowledge transfer tool with several limitations. One of the line managers says that those who can first sift out all the redundant rubbish on the Internet will win. Another line manager asserts that the Internet can help consultants with the first information about something new, but that the consultants then have to proceed to books and reference objects to get deeper knowledge.

Pointers to knowledge such as knowledge maps seem to be a usual start for knowledge management initiatives in practice. One of the consultant companies had recently introduced an intranet based system for mapping the knowledge of the employees this system, called KnowMan, builds on the active participation and contribution of all employees. The respondents said that one individual incentive to contribute to such a system is to advertise one's own competence and experience and thereby more easily become involved in interesting projects.

Knowledge mapping tools

Knowledge and information mapping technology as an enabler concerns management of all kinds of electronic memory such as databases and track-records from digital communication tools such as e-mail. When it comes to storing knowledge in databases the four companies do much the same. Databases and files from the projects are stored on file servers and there are special arrangements that keep track of the documents, different versions and their origins. The situation is similar for tracking e-mail traffic and discussions in work groups. However, one company has had a document management system for some years. This system has helped the company to provide templates and to manage documents consistently, irrespective of what department produced it or who was project manager. This document management system was to be replaced by a new software platform then

under development and that will include a document management system. Two of the other three companies are implementing similar platforms. Such software platforms are also intended to allow all employees to reach the company network from all over the world via the Internet and a personal portal. However, it should be noted that computer based document management systems is a new phenomenon in these companies.

Earlier in this chapter (section 5.1.3) it was concluded that business processes were well mapped and developed in the four companies. It could therefore have been expected that the traditional management system would have been replaced by a process oriented web based workflow system linking information in various databases, file servers, mail servers and documents to particular activities. However, no such workflow system was found in operation in the four companies covered by the study.

Memory tools

The largest digital sources of information or digital memories for the four companies more identified as the Internet, intranets and internal databases. Intranets contain a mix of documents and databases. Most of what can be found by using the intranet is stored as files (Word, Excel, CAD) on file servers. Documentation from projects where files can be available on the intranet is one example. All four companies have a database where they store information about their employees (CV database) and all four have local project databases or project servers at each office. All companies also have reference databases, and some have CAD databases where the consultants can retrieve old design solutions and objects. The knowledge management literature emphasizes multimedia applications such as video for capturing knowledge and storing it in knowledge databases. There is no obvious sign of such applications in the four companies. None of the companies has implemented a system making it possible to search and retrieve information simultaneously from all databases; there was no direct connection between the databases and they had to be coordinated manually.

To some extent, project management tools can be interpreted as memory tools. It is seldom that technical consultants use project management tools such as MS Project or Prima Vera for planning and coordinating projects. The empirical studies show no signs at all of specialized software for scheduling. Instead project managers use templates, usually in Excel, as a basis for their project management. At one company the department manager who was interviewed had built a project management tool with a considerable number of linked Excel spreadsheets, a tool that he wants his project managers to use. This tool makes it easier for him to monitor and aggregate all projects at the department in weekly reports. There have been attempts to transfer this

model to other departments and offices but it has not become widely used. Thus there are no workflow systems in evidence that allow the consultant to schedule, make reports, treat non-conformances, monitor finance and quality in an IT environment where everything is integrated and linked.

CAD has successively become a system for facilitating collaboration across disciplinary boundaries. All four companies use more than one system and more than one release. It is usually the client or the client project manager who decides which tools and which release are going to be used. This is expensive for the technical consultant companies because they have to buy many licences and learn new applications and releases for almost every project. When learning a new system, consultants sometimes work with two applications in parallel so that there is always a copy in a well known application. Since 1998 CAD has taken on several 3D based features, especially for civil engineering tasks such as roads and railways, but it is still unusual to use object oriented CAD. Moreover, especially in the context of civil engineering projects, CAD tools are not just used to make drawings any longer. Some CAD tools integrate design and calculation, which brings these new tools closer to what the name has promised for years - Computer Aided Design.

Knowledge combination tools

By spring 2000, no advanced tools for knowledge combination, such as intelligent agents or network mining tools were used in the four technical consultancy companies studied.

5.2.3 Enabling conditions and facilitating activities in the knowledge transfer process

Although all knowledge transfer sub-processes can be stimulated by enabling conditions and facilitating activities, there is reason to believe that the technical consultancy companies have distributed their efforts so that the impact on individual sub-processes varies. Table 5.4 shows in which sub-processes initiatives described in the previous two sections were taken by the four companies and how the four categories of technological enabling tools can be assigned to individual sub-processes.

Table 5.4 Current measures according to enabling conditions and facilitating activities and their role as support for the five knowledge transfer sub-processes.

Enabling conditions and facilitating activities	Knowledge transfer sub-process				
	A	D	M	O	R
1. Organizational structure	X	X		X	X
2. Communication and monitoring of strategy		X	X		
3. Process	X			X	
4. Culture		X	X		
5. Systems for training and learning		X	X	X	
6. Technology					
6.1 Knowledge transfer tools	X	X	X		X
6.2 Knowledge mapping tools	X			X	X
6.3 Memory tools				X	
6.4 Knowledge combination tools					

Knowledge transfer sub-processes: (A) Acquisition, (D) Distribution, (M) Making meaning, (O) Organizational memory, and (R) Retrieval. The X indicates that something is done in the technical consultant companies that can be assigned to both the enabler/facilitator and the sub-process.

When it comes to organizational enablers and facilitators, the four companies attempt to use organizational structure to give access to knowledge holders and to facilitating sharing of various categories of knowledge. If the organizational structure enables consultants to meet more easily, it will also enable and facilitate distribution and making meaning. Few serious attempts have been made to create a shared language that can enable efficient storage of knowledge. Surprisingly, although technical consultancy has a long tradition, enshrined in a professional language, this was said to be not very useful for communication and codification of knowledge. Attempts have instead been made to develop a leadership that enables communication. From a process perspective all four companies have made attempts to capture explicit knowledge and store it in databases, but capturing experience from projects has not been successful at the organizational level, even when there are lessons leaned meetings and final reports. Exposure to external sources occurs, both in projects with a broad range of participants and by reading texts in books, magazines, the press and on the Internet. The culture is informal and it is easy to meet and talk to colleagues. There are also formal meetings where the consultants are exposed to new knowledge and information. Thus the culture should enable and facilitate distribution and making meaning of information and knowledge. Finally, systems for training and learning enable and facilitate the sub-processes of distribution and organizational memory through training and making meaning through team learning and discussion in teams.

The technological enablers (6.1-6.4 in table 5.4) have to be compared with the examples listed in Table 2.6 in the literature review. Table 2.6 shows that not all the categories of technological enablers support all the sub-processes. Comparing Table 5.4 with 2.6, it can be seen that the first three categories of technological enablers (knowledge transfer tools, knowledge mapping tools and memory tools) are marked in every cell. However, no tool has been focused in the four companies corresponding to the knowledge combination

tool category, which appears to require a more advanced generation of software support, presupposing an integrated system of company databases.

5.3 Summary

Soon after the introduction of intranets in the four studied companies during the autumn of 1997, several services related to transfer of knowledge appeared on the intranets. Quality assurance systems were one of them, but these systems were still only available as digital documents in PDF format. CAD applications were still two-dimensional, although limited parts of some projects were handled with three-dimensional CAD. A few CAD databases had emerged and the management terminology had changed from experience feedback to knowledge management. The technical consultants still thought of their roles as being intermediaries of knowledge in construction.

In technical consultancy organizations such as these four companies traditionally there are four functional layers based on individual knowledge, with the intention to certify knowledge instead of using formal processes and standard procedures for the technical professional tasks. This creates a large element of inertia if strategies need to be changed. However, business processes have been mapped by the companies and the formal processes are kept in the quality assurance system. Making meaning is the most frequent knowledge transfer sub-process within the business processes. Making meaning is one of the knowledge transfer sub-processes included in the reviews that are such a frequent feature of projects undertaken. During the realization sub-process, there are also many informal reviews in the daily work where two or more consultants have time for reflection and making meaning of what has been done, of new requirements, a new problem, or a solution to a problem. It must also be noted that when knowledge crosses organizational boundaries, there are special routines to certify the knowledge transferred. Having a certified employee sign the output is such a procedure.

All the companies studied have started to think in terms of managing knowledge and have realized that the organizational structure affects how and what knowledge that will be transferred. Responsibility for knowledge management had not been clearly assigned in any of the companies, but an awareness of the field of knowledge management had begun to affect general leadership issues. It has become clear that knowledge is tied to strategy and that three of the four companies have knowledge management in their business concepts. Most knowledge acquired in projects are tacitly stored in the brains of the consultants. Best practice solutions are therefore difficult to retrieve, unless it is possible to meet an expert who has designed a good solution and ask for advice. Although most of the knowledge about

performing the professional tasks seems to be tacit, there have been some initiatives to manage explicit knowledge, preferably by storing it in databases. The interviews showed that there were many opportunities for employees to meet and communicate. Open access to information exists with exceptions such as digitally stored information from other departments, available only by special permission. Among other cultural issues it was found that there were no rewards for transferring knowledge. This lack of clear appreciation applies both to using knowledge and to contributing to the organizational memory. When it comes to feedback, the only formal feedback system for learning was performance appraisal systems. Evaluations are often annual and were therefore regarded as a slow feedback system.

When it comes to the technological enablers, all of the companies have focused during 1998 to 2000 on creating their common hardware and software platforms. Such a platform is expected to provide a solid foundation for other technology based knowledge management initiatives, and it has been prioritized by senior management. Much work has also been done with various CAD tools and the introduction and development of intranets. Although many tools are available, they have not yet become widely used. E-mail has to a large extent replaced the facsimile and sending floppy disks by traditional mail or courier. However, there are as yet no signs of using net-meetings and other groupware tools for interactive collaboration.

6 Knowledge management, the 1997-98 study

This chapter presents the results from the first study, carried out between September 1997 and February 1998. At each of the companies one department was studied using a number of methods (see section 4.4.1 and 4.4.2) and in the questionnaire survey, the number of departments surveyed at each company was extended to two or three (see section 4.4.3). Most results in this chapter are based on the competence and knowledge questionnaire with a few contributions from interviews, documents and observations to provide a more detailed presentation. Results are presented in three sections beginning with a correlation analysis of the background variables, followed by a presentation of the knowledge transfer process and, finally, results from how learning and knowledge transfer were organized related to enabling conditions and facilitating activities.

6.1 Relations between the background variables

Correlation analysis was performed on background variables in the questionnaire survey (see Table 6.1). The gender variable has significant correlations at the 0.01 level to age (0.25), function (0.31) and time at company (0.25). These correlations imply that male consultants are usually older and have been employed longer than female consultants, and that males also occupy more advanced functions. As expected, there are strong positive correlations between age and the time a consultant has had the same kind of tasks (0.66) and for how long they have been employed in the company (0.60). Age also correlates positively with function (0.21) and negatively with education (-0.27). Correlation is lower between age and function (0.21) but it is likely that older consultants have more advanced functions than younger consultants and that they are not as well educated as their younger colleagues.

Table 6.1 Nonparametric correlations of background variables (Kendall's t_b).

Background variables	Gender	Age	Function	Time with task	Time at company	Education	Task
Gender	1	0.25**	0.31**	0.22*	0.25**	0.07	-0.11
Age	0.25**	1	0.21**	0.66**	0.60**	-0.27**	-0.07
Function	0.31**	0.21**	1	0.15	0.14	0.15	-0.16
Time with task	0.22*	0.66**	0.15	1	0.54**	-0.34**	-0.13
Time in company	0.25**	0.60**	0.14	0.54**	1	-0.22**	-0.11
Education	0.07	-0.27**	0.15	-0.34**	-0.22**	1	-0.21*
Task	-0.11	-0.07	-0.16	-0.13	-0.11	-0.21*	1

* Correlation is significant at the .05 level (2-tailed).
** Correlation is significant at the .01 level (2-tailed).
Gender code: Females (= 0) and Males (= 1).
Task code: Feasibility studies (= 1), Conceptual design (= 2), Detailed design (= 3), Inspection (= 4), and Administration (= 5).

Time with the same kind of task correlates as mentioned with age, but also with time employed at the company (0.54) and negatively with education

(-0.34). Time at the company also correlates negatively with education (-0.22). It is therefore likely that respondents who have worked for a long time with the same kind of tasks or have been employed for a long time at the same company will have less education. When answering the task question the respondents had to decide what was their major category of task. Five alternatives were given: (1) feasibility studies, (2) conceptual design, (3) detailed design, (4) inspection, and (5) administration. Correlations were generally negative and lower than for other variables, and there was no significant correlation at the 0.01 level to other background variables. There was a negative correlation to education with significance at the 0.05 level. This can be interpreted to mean that respondents with more education usually do more of the first two categories of tasks[30]. To conclude, the age variable seems to be the crucial background variable since it is significantly correlated to all the others, except the task variable.

6.2 The knowledge transfer process

Many of the questions concerning methods for competence development and learning in the questionnaire survey can be assigned to one or more knowledge transfer sub-processes identified in Chapter 2[31]. More precisely, there are 66 statements where respondents have coded their degree of agreement on a Likert-style scale. The aim of this section is to present what methods are used in the five sub-processes and thereby to provide an understanding of how technical consultants transfer knowledge and information.

6.2.1 Acquisition

The first sub-process is acquisition. Using the categorization of methods for knowledge and information acquisition into internal and external methods as proposed in section 2.6.2, out of the 66 survey questions with a Likert-style of scale, 20 could be referred to acquisition (see Table 6.2). Internal methods were perceived by respondents to be the most useful ways of acquiring knowledge and information. Acquiring individual experience by, for example, experimenting and trying out various solutions to a problem had the highest mean value (mean 7.2). The second most useful method was perceived to be

[30] However, line managers usually answered category five (administration). As all line managers with one exception were civil engineers and consequently ranked high on the educational scale, there are many well educated respondents at each end of the scale and few in the middle.

[31] When e.g. assigning responses to the question "I learn things I can use in my work by daily conversations with colleagues" to no less than four sub-processes: acquisition, distribution, making meaning and retrieval, there is a slight loss in validity, since the original question is phrased only in terms of learning and thus related more obviously to just knowledge acquisition and knowledge retrieval.

that the internal project team uses “previous projects as best practice and sources of knowledge and information” when beginning a new project (mean 6.9). This is followed by talking to colleagues (mean 6.6) and that the individual consultant using experience from previous projects (mean 6.1).

Still on the upper half of the scale, but valued as “more or less” useful, is a mix of internal and external methods. External courses (mean 5.6), professional journals and magazines (mean 5.5), training and courses (mean 5.5), and learning from clients (mean 5.4). Training and courses can be classified as both an internal and an external method. Another internal method is based on making experience: trying different tasks and planned supervision (mean 5.6).

Table 6.2 Perceived usefulness of various methods for knowledge and information acquisition.

Methods	I/E	N	Mean	SD
I learn a great deal I can use in my work by experience	I	101	7.2	1.4
The project team (if there is one) within the company use previous projects as best practice when they work with a new project	I	94	6.9	1.3
I learn things I can use in my work by daily conversations with colleagues	I	101	6.6	1.4
I use experience from my company's previous projects that I have learned from others as best practice when I participate in a new project	I	101	6.1	1.6
I learn a lot by participating in external courses	E	91	5.6	2.1
I learn in my work by trying different tasks and by planned supervision	I	100	5.6	2.2
I learn by reading professional journals and magazines	E	100	5.5	1.6
I learn things I can use in my work by participating in training and courses	I/E	100	5.5	1.6
I learn things I can use in my work from contact with clients	E	101	5.4	2.1
I learn by reading books	E	100	5.0	2.0
I use information from the company library in my work	E	100	4.7	2.8
I learn a lot by reading scientific journals	E	100	4.6	2.1
I learn things I can use in my work from contact with other technical consultants	E	101	4.6	2.0
I learn things I can use in my work from contact with suppliers	E	101	4.6	2.2
I learn a lot by participating in internal courses	I	96	4.6	1.9
I learn things I can use in my work from contact with users	E	100	4.4	2.3
I learn things I can use in my work by talking to colleagues in my company but outside my office/department	I	101	4.4	1.9
I learn things I can use in my work from contact with architects	E	101	3.8	2.2
I use knowledge and information from the intranet in my work	I	101	3.3	2.2
I use knowledge and information from the Internet in my work	E	101	3.2	2.2

I/E: (I) Internal acquisition and (E) External acquisition. N: Number of responses. SD: Standard deviation.

The lower half of the scale is dominated by external methods. First there are three methods by which the consultants use textual documents to acquire knowledge and information. These methods are followed by communication with external actors such as other technical consultants, suppliers and users. Receiving the same score as user and slightly higher than for architects, is learning internally from colleagues at other departments and offices. It is interesting to see that colleagues in the same company are perceived as less useful for knowledge and information acquisition than a handful of external actors. It should also be noted that the intranet (mean 3.3) and the Internet (mean 3.2) are perceived as “no, just slightly” useful for acquiring knowledge and information. The correlation between the use of the intranet and the Internet is high (0.55) and it can be expected that people who use the intranet also use the Internet. All four companies in the study had their quality assurance systems published on their respective intranets, but at the time of

the study only one of them had the intranet as the only publishing medium. The use of the Internet has a low (-0.22) but significant correlation to age indicating that younger consultants find the Internet more useful than the older tend to do.

The client seems to be the most important person as a source of knowledge and information external to the company. Every consultant has a client but not all consultants interact frequently with users and architects. Geotechnical, bridge and highway engineers do not meet architects and users as often as those specialized in building services engineering and structural engineering do (see section 4.5.1). Many interview respondents stated that what they learn from external sources is exclusively background knowledge, which is good to know, but not necessary for producing the service they are expected to perform. However, they also stated that much of the learning in interaction with the client can also be part of learning and understanding what the client needs and wants so that the expectations of the client will be met in the end.

Correlation between background variables and knowledge transfer process variables is generally low and insignificant in the context of the sub-process of acquisition, although there are noticeable correlations between the possession of a more advanced function and learning from clients (0.34) as well as between function and learning from users (0.31). The interviews also show that the companies had not yet (in January 1998) started to map external knowledge such as customer knowledge in a systematic way for publication on an intranet or using other IT means for easy access.

In Chapter 4, section 4.5.1, it was found that specialization had an influence on learning when it came to acquiring knowledge and information from architects (mean 3.8). The first distinction made was between specializations in buildings (houses) and civil works. Consultants who are specialized in building design meet architects much more frequently than consultants specialized in civil engineering, and the former would therefore find architects a more useful source of knowledge and information than those specialized in civil engineering would. A dummy variable "Building/Civil" was introduced to investigate the difference. Nonparametric correlation (Kendall's t_b) between the new variable and learning from architects showed a high (0.45) correlation significant at the 0.01 level, implying that consultants specialized in buildings (mean 4.8) learn from architects to a larger extent than consultants specialized in civil works (mean 2.5).

Consultants specialized in buildings also perceived that they learned slightly more from users (mean 4.8) than consultants specialized in civil works did (mean 4.0). In one company, where the studied specialization within buildings was building services engineering, learning in the interaction with users scored

higher than for any other specialization (mean 5.7). This may be the case because designing building services, their function and placing, simply requires more user involvement than the other specializations. Although the scores for the discussed external methods thus vary across the specializations, they are lower than for the group of internal experience based and face-to-face communication based methods for knowledge and information acquisition, where on the other hand little difference was found between the specializations.

One group of external methods for acquiring knowledge and information is physically available within the company, or even at the department, although the knowledge stems from external sources. This is explicit knowledge captured in published material such as books, journals and magazines. At three of the four departments where observations were made, there was a library in the offices, consisting of anything from shelves containing up-to-date books, product catalogues, and magazines to personal books and collections of reports. The employees at all three departments knew about and used the libraries in their work (mean 4.7, but in two of the companies mean values at the surveyed departments were 6.9 and 6.0, respectively). At one company, the studied department lacked a proper library, but kept old norms and regulations on a few shelves in a corridor. They did neither have a collection of journals or magazines. Employees used their few library resources much less (mean 1.8) than at the other departments, and this department obviously relied more heavily on human sources.

It can be concluded from the discussion above that two internal methods, experience based and face-to-face communication, are perceived as the most useful methods of knowledge and information acquisition. With the exception of training, which shares features of internal and external methods, the internal methods were followed in rank by external text-based methods available in the office. On the lower half of the scale are to be found external methods, primarily communicative methods mostly involving external actors.

6.2.2 Distribution and making meaning

Eight questions related to the two sub-processes of distribution and making meaning were included in the questionnaire survey. According to Table 6.3, the most useful method for distributing knowledge and information was daily conversations with colleagues (mean 6.6) and helping colleagues and others[32] (mean 6.4). Both these methods are largely based on informal face-to-face communication. They are followed in importance by four methods related to

[32] "Others" refers to individuals not employed in the same company.

training situations of which all except learning from superiors are of a formal character. At the time of the 1997-98 study, training was associated in the four companies with meeting face-to-face and talking. Web-based training did not yet exist and training videos were not used. Another informal method that comes lower down the scale was learning from colleagues at other departments and offices. Again, the usefulness of the company intranet was considered to be low as was the case with knowledge and information acquisition.

Table 6.3 Perceived usefulness of methods related to distributing and making meaning.

Method	N	Mean	SD
I learn things I can use in my work by daily conversations with colleagues	101	6.6	1.4
I learn by helping colleagues and others	101	6.4	1.5
I learn in my work by trying different tasks and by planned supervision	100	5.6	2.2
I learn things I can use in my work by participating in training and courses	100	5.5	1.6
I learn things I can use in my work from contact with superiors	101	5.0	1.9
I learn a lot by participating in internal courses	96	4.6	1.9
I learn things I can use in my work by talking to colleagues in my company but outside my office/department	101	4.4	1.9
I use knowledge and information from the intranet in my work	101	3.3	2.2

N: Number of responses. SD: Standard deviation.

It can be concluded that informal communicative methods with the colleagues at the department are perceived as the most useful methods for knowledge and information distribution and making meaning. Again, the emphasis is on internal rather than external methods.

6.2.3 Organizational memory

Only three assertions, all of them belonging to internal methods, can be allocated to the sub-process of organizational memory. The first is related to intentionally storing knowledge in other individuals by passing along to them knowledge learned at courses and training. This statement is “I’m expected to report on knowledge I have learned at a course/training to my colleagues” (mean 6.5, standard deviation 2.4) and among the background variables it correlates positively with the possession of a more advanced function in the company (0.35). The other two statements are related to company internal transformations and processes where knowledge and information are stored. The second is “Suggestions and proposal are taken seriously at my company” (mean 6.1, standard deviation 1.5) and the third is “I believe quality audits are good opportunities for learning” (mean 5.5, standard deviation 2.1). With only three questions referring to aspects of organizational memory, no pattern can be detected. However, there is a clear acknowledgement of the usefulness of three internal methods.

6.2.4 Retrieval

Respondents are close to reaching a consensus that using best practice from previous projects is the best category of methods for retrieving knowledge and information. First in importance is using one's own experience (mean 7.7), then by the team using their knowledge together (6.9) and scoring slightly lower, using knowledge learned from others (mean 6.1) (see Table 6.4). Learning by daily conversations with colleagues (mean 6.6) can also be assigned to this first category of methods. All four methods in the first category are to a large extent related to intradepartmental retrieval of knowledge and information, although use of knowledge that has been learned by others can be integrated as extradepartmental retrieval. Interviews with the consultants showed that the best way to find something out is to go out in the corridor and ask someone that knows. This informal method used, according to the respondents, to give fast and good answers. Another advantage mentioned with using informal methods including face-to-face discussion was that the questions did not have to be carefully formulated.

Table 6.4 Perceived usefulness of methods related to retrieval of knowledge and information.

Method	N	Mean	SD
I use my experience from previous projects as a best practice when I participate in a new project	101	7.7	1.0
The project team (if there is one) within the company use previous projects as best practice when they work with a new project	94	6.9	1.3
I learn things I can use in my work by daily conversations with colleagues	101	6.6	1.4
I use experience from my company's previous projects that I have learned from others as best practice when I participate in a new project	101	6.1	1.6
I believe quality audits are good opportunities for learning	100	5.5	2.1
I learn things I can use in my work from contact with superiors	101	5.0	1.9
I learn things I can use in my work at internal professional seminars	91	5.0	2.1
I learn things I can use in my work by talking to colleagues in my company but outside my office/department	101	4.4	1.9
I use knowledge and information from the intranet in my work	101	3.3	2.2

N: Number of responses. SD: Standard deviation.

Quality audits (mean 5.5), superiors (mean 5.0), internal professional seminars (mean 5.0), and interdepartmental learning from colleagues rank lower. As before, use of knowledge and information from the company intranet was rated at a low level, probably depending on the novelty of this tool and its initial lack of rich context. As with the earlier sub-processes of knowledge transfer, internal methods dominate with a preference of each individual's immediate surroundings.

6.3 Enabling conditions and facilitating activities

While the first part of the questionnaire contains statements related to transfer sub-processes and the usefulness of associated methods, the other four parts can be assigned to the statements belonging to types of enabling conditions and facilitating activities presented in section 2.7. The aim of the present section is to investigate how learning and knowledge transfer were supported

by enablers and facilitators in the companies during the period of the 1997-98 study.

6.3.1 Organizational structure

Organizational structure is the first type of enabling conditions identified in Chapter 2. The questionnaire contains four questions on knowledge erosion, which occurs when a consultant leaves the company (see Table 6.5). Departure of an employee could have effects on organizational structure. On average, many respondents did not appear to be reluctant to change jobs (mean 5.5) or take a similar job at another company at the time for the study (mean 5.3). There is little variation depending on the age of the respondents. However, respondents above 60 wanted to stay at their work or in their companies to a much larger extent than their younger colleagues.

In a five-year perspective, the differences between age groups are slightly more pronounced. The youngest (20-25 years) were conspicuous for answering that they did not expect to work at the same company (mean 3.8) or have the same job in five years (mean 3.8). Standard deviations for both variables are low, which implies that there was general agreement within this group, but the number of respondents was low compared with the other age groups. The second youngest group (26-30 years) also tended to answer that they did not expect to work at the same company (mean 4.8) or have the same job in five years (mean 4.8). At the other end of the age scale, those who would approach retirement (50-60 years of age), scored higher (mean 6.4 and mean 6.7) on the same questions. There is also a link between education and the individual employment situation in five years. Well-educated respondents appear to be less loyal to the company than the others.

Table 6.5 Four knowledge erosion assertions: attitudes in six age intervals.

Assertion	Stat.	Age interval					
		20-25	26-30	31-40	41-50	51-60	>60
If I got a chance to take a similar work at another company, I would do so	N	4	12	22	24	22	16
	Mean	6,0	6,3	5,4	5,4	6,0	3,6
	SD	1,4	1,7	1,9	1,6	1,6	2,3
If I had a chance to take another job, I would do so	N	4	12	22	24	22	16
	Mean	5,3	6,5	5,5	6,0	5,6	3,8
	SD	1,7	2,2	1,9	1,4	1,9	2,4
I will probably work at the same office in five years	N	4	12	22	24	22	Ret.
	Mean	3,8	4,8	5,6	6,0	6,4	
	SD	1,0	2,0	1,9	1,7	1,9	
I will probably still work at the same company in five years	N	4	12	22	24	22	Ret.
	Mean	3,8	4,8	5,8	6,3	6,7	
	SD	1,0	2,0	1,8	1,6	1,8	

Ret. = Retired in five years as the normal retirement age for Swedish technical consultants is 65 years.
N: Number of responses. SD: Standard deviation.

It can be concluded that younger consultants are more mobile than their older colleagues, both when it comes to changing jobs and changing companies. This will have implications not only for new recruitment, but also as one

executive officer said in an interview in the second study (2000), for finding employees in the 30-40 years age group who can serve as department managers. In short, if there is a problem of knowledge erosion, it depends on age, and it is less the older and more experienced consultants who may cause erosion. Organizational structure will have to match the greater mobility of younger employees.

6.3.2 Communication and the monitoring of strategy

Because of high intercorrelations among survey responses, questions related to organizational rewards stand out among enablers and facilitators that support communication and the monitoring of strategy (see Table 6.6).

Nevertheless, organizational rewards are generally perceived to be low. Table 6.6 includes variables interesting from a reward perspective (variables 1, 2, 3, 5, and 7) because they can be seen as traditional indicators of outcomes of a motivated and rewarded organization. The consultants feel only weakly rewarded for learning at work (mean 5.3). Process support tools (software, routines and hardware such as computers, faxes and copiers) are found to be suitable, but not strongly (mean 7.0). The consultants also perceive that there are few opportunities to make a career by doing a good job (mean 5.5). New ideas and initiatives are not felt to be much encouraged (mean 6.3) and suggestions and proposals are taken seriously only to a limited extent(mean 6.1). Hence, it could be expected that consultants would leave the company if the opportunity arose, but the reaction to that statement was close to neutral (mean 5.5). It is surprising to find that the propensity for changing jobs does not correlate significantly with the variables that represent organizational rewards.

The feeling of opportunities to make a career by doing a good job correlate with the feeling of encouragement of new ideas (mean 6.3), helping and supporting each other at work (mean 7.4), listening to suggestions and proposals (mean 6.1), and rewards for learning (mean 5.3). The perception of “getting a lot done at work” (mean 7.1) correlates positively with “working with good and suitable tools” and with “encouragement for new ideas and initiatives”. The tendency to acknowledge rewards for learning have a high correlation with encouragement for new ideas (0.45), suggestions and proposals being taken seriously (0.44), and good opportunities to make a career by doing a good job (0.49).

Table 6.6 Assertions related to organizational rewards. Nonparametric correlation (Kendall's t_b) of responses.

	Variables	1	2	3	4	5	6	7	8	Mean	SD
1	We help and support each other at work	1	0.18	0.27**	0.37**	0.32**	0.34**	-0.19	0.31**	7.40	1.6
2	I get a lot done at work	0.18	1	0.29**	0.22**	0.10	0.11	-0.21	0.19	7.10	2.0
3	The tools (resources) work well and are appropriate	0.27**	0.29**	1	0.12	0.19	0.14	-0.10	0.18	7.00	1.3
4	New ideas and initiatives are encouraged	0.37**	0.22**	0.12	1	0.68**	0.43**	-0.12	0.45**	6.30	1.5
5	Suggestions and proposal are taken seriously at my company	0.32**	0.10	0.19	0.68**	1	0.41**	-0.08	0.44**	6.10	1.5
6	There are good opportunities to make a career by doing a good job	0.34**	0.11	0.14	0.43**	0.41**	1	-0.14	0.49**	5.50	1.9
7	If I got a chance to take another job, I would do so	-0.19	-0.21	-0.10	-0.12	-0.08	-0.14	1	-0.14	5.50	2.0
8	We are rewarded for learning at my job	0.31**	0.19	0.18	0.45**	0.44**	0.49**	-0.14	1	5.30	1.8

** Correlation is significant at the 0.01 level (2-tailed).
SD: Standard deviation.

Most assertions about communication and monitoring of strategy in the questionnaire are related to organizational rewards. It can be concluded that organizational rewards are generally perceived as low. However, from an improvement perspective, it is interesting to find that rewards for learning have a high correlation with encouraging new ideas, taking care of suggestions and proposals seriously, and good opportunities to make a career by doing a good job.

6.3.3 Process

The questions related to both the content of work and the freedom of work were designed so that they would indicate how process enablers and facilitators were perceived by respondents. The content of work should influence the number of possible occasions for learning and knowledge transfer. Problem solving and high complexity can be expected to encourage learning and promote motivation as well as learning associated with face-to-face communication and discussion, which were found earlier in this chapter to be the most useful methods for acquiring knowledge. What can be seen in Table 6.7 is that challenges and new demands in daily work are marked as above average (mean 6.9) as well as alternation and variation in work (mean 7.1) and use of competence (mean 7.3) which both scored even higher. Most respondents feel motivated and believe their work is meaningful (mean 7.3),

an opinion that might be thought to be in conflict with a feeling of absence of organizational rewards. Respondents feel involved in their work and often do more than expected (mean 7.2) as well as thinking they get a lot done at work (mean 7.1). The respondents experience participation in problem solving (mean 7.8) and also feel they learn by helping colleagues solve their problems (mean 6.3).

Table 6.7 Assertions related to loyalty and problem solving. Nonparametric correlation (Kendall's t_b) of responses.

	Variables	1	2	3	4	5	6	7	8	9	10	11	Mean	SD
1	Function	1	0.54	0.24	0.39	0.66	0.35	0.28	0.35	0.30	0.29	0.40		
2	I contribute to solving most problems that occur in my job	0.54	1	0.38	0.37	0.48	0.37	0.30	0.29	0.30	0.29	0.39	7.7	1.4
3	My work is meaningful and I feel motivated	0.24	0.38	1	0.46	0.28	0.54	0.44	0.31	0.36	0.34	0.24	7.2	1.4
4	I'm loyal to my company and give up my private life for work	0.39	0.37	0.46	1	0.38	0.68	0.44	0.38	0.33	0.35	0.31	7.2	1.9
5	I plan my work	0.66	0.48	0.28	0.38	1	0.34	0.28	0.32	0.32	0.22	0.32	7.2	1.8
6	I'm involved in my work and often do more than expected	0.35	0.37	0.54	0.68	0.34	1	0.44	0.37	0.33	0.35	0.28	7.1	1.6
7	My work is varied and alternated	0.28	0.30	0.44	0.44	0.28	0.44	1	0.30	0.65	0.15*	0.21*	7.0	1.4
8	I'm expected to share knowledge and experience with colleagues at my company	0.35	0.29	0.31	0.38	0.32	0.37	0.30	1	0.33	0.33	0.42	6.9	2.0
9	My work contains elements of new demands and challenges	0.30	0.30	0.36	0.33	0.32	0.33	0.65	0.33	1	0.25	0.23	6.8	1.5
10	I often take the initiative to new solutions and work processes at work	0.29	0.29	0.34	0.35	0.22	0.35	0.15*	0.33	0.25	1	0.40	6.4	1.6
11	I often help others to solve problems that occur at work	0.40	0.39	0.24	0.31	0.32	0.28	0.21*	0.42	0.23	0.40	1	6.3	1.8

* All correlations are significant at the 0.01 level (2-tailed) *except* these two.
SD: Standard deviation.

There is one group of highly correlated variables related to loyalty and problem solving that can be assigned to content of work and processes. Involvement in work and loyalty have the highest correlation (0.68) and involvement is strongly correlated with meaningful work and motivation (0.54). On the problem solving side, planning of work has high correlations with function (0.66) and contribution to solve problems in work (0.48). There is also a high correlation between new demands and challenges and on the other hand variation in work (0.65). For most variables, the age variable has higher correlation and level of explanation than the gender variable. There is also an intercorrelation between the background variables that implies that most of the responding women are young. An example of this is the significant correlations (0.01 level) between male gender and the assertion "I plan my work" (see Table 6.7) and between high age and "I plan my work" where the later correlation is slightly higher. Concerning the other assertions in Table 6.7, three of them were found to be significantly correlated (0.01 level) with male gender and function but not with age. Thus, it was found that men in higher positions tended to perceive higher loyalty to the company and that they give up their private life for work, also that they are more involved in the work and often do more than expected, and finally that they help other

colleagues to solve problems more often than females in lower functional positions in the company.

Whereas men tend to hold higher positions in these departments, the gender variable had low but significant correlation to six (number 4, 5, 6, 8, 10 and 11 in Table 6.7) of the eleven variables representing loyalty and problem solving.

Another group of assertions related to processes, close to the content of work, is about routines, especially quality assurance (see Table 6.8). Correlations are high and significant at the 0.01 level with only one unimportant exception that reflects the weakness of links between environmental performance and quality audits. The quality assurance system is obviously relevant for a process description. In interviews, the respondents said that although the systems are on the intranet, almost all the project managers have their own adaptations of the process depending on the character of the specific project. As already mentioned in section 5.1.3, one of the companies described its assignments in three categories according to size and technology used, from advanced to small assignments. The formal parts of the project management process described in the general management system were simplified for smaller projects, but these were based on the same process. Assertion variables related to process routines have mean values close to 5.5, the mean value of the scale used in the questionnaire. Routines and checklists such as those in the quality assurance manual seem not to be particularly valuable resources for the consultants (mean 4.9). This assessment of the quality assurance system correlates highly with the perception that it is not personally developing to work with such systems (mean 4.6), that they are not easy to use (mean 4.5), and that they nevertheless are often used (mean 5.9).

Table 6.8 Assertions related to routines. Nonparametric correlation (Kendall's t_b) of responses.

	Assertions	1	2	3	4	5	6	7	Mean	SD
1	I use the quality assurance manual in my work	1	0.38	0.32	0.46	0.57	0.50	0.55	5.9	2.2
2	I believe my company's customers are positive about how we assure quality	0.38	1	0.25	0.42	0.48	0.46	0.40	5.9	1.9
3	I consciously try to produce an output with good environmental performance	0.32	0.25	1	0.18*	0.36	0.34	0.32	5.8	2.2
4	I believe quality audits are good opportunities for learning	0.46	0.42	0.18*	1	0.49	0.54	0.45	5.5	2.1
5	I think routines and checklists in my company's quality assurance manual are valuable resources in my work	0.57	0.48	0.36	0.49	1	0.76	0.69	4.9	2.1
6	I believe it is personally developing to work according to the routines in my company's quality assurance manual	0.50	0.46	0.34	0.54	0.76	1	0.65	4.6	2.1
7	I think it is easy to use the routines in my company's quality assurance manual	0.55	0.40	0.32	0.45	0.69	0.65	1	4.5	1.9

* All correlations are significant at the 0.01 level (2-tailed) *except* this.
SD: Standard deviation.

The low use of the quality assurance manual as reported by respondents may depend on the use of individual adaptations or interpretations of the content of the manual. As individual interpretations will not be shared or only

imperfectly shared among the consultants, this more informal method of working does not provide good support for knowledge transfer or use of shared processes in the company. Perceptions of how customers perceive quality assurance in the assignments are also low (mean 5.9). If the consultants themselves do not believe in their quality assurance systems, who will?

After statements related to the content of work, the second section in the questionnaire that can be assigned to processes is related to the freedom of work, which concerns giving employees an opportunity to influence their work, set their agenda and reserve time for the analysis, reflection and interpretation that are necessary to achieve learning and transfer of knowledge. Here, the respondents perceive that they participate in the planning process (mean 7.8) and also do much of the planning themselves (mean 7.3). Their work is just as much routine as not (mean 5.0) and quality assurance is, to a large extent, managed by the individual employee (mean 7.9). However, there is little time to catch up with work if someone has been absent (mean 5.7) and there is no strong feeling that there is time to learn about things that are important for the job (mean 5.0).

It can be concluded that there is a widespread perception of freedom of planning and problem solving when working. Among the job characteristics, the tasks are perceived as challenging and varied and the respondents feel that they use their competence in what they do. However, routines described in the quality assurance system are not easy to use, which correlates with low use and the perception that it is not personally developing to work according to these routines. Freedom of work is also closely related to organizational culture, but the assertions used in this section of the questionnaire were more related to process issues.

6.3.4 Organizational culture

Organizational culture is often referred to when authors on knowledge management discuss enabling conditions for learning and knowledge transfer (see section 2.7.1). Much of what has already been said about organizational rewards earlier in the present chapter also expresses what characterizes an organizational culture that enables learning and knowledge transfer. High scores on several related assertions from the questionnaire indicate support for a learning culture, but there are also scores close to neutral (5.5). Thus the respondents experience that they are expected to support colleagues (mean 7.5) and to share knowledge (mean 7.0). Nevertheless, returning from a course does not necessarily mean that they are expected to report and share what they have learned (mean 6.6) with colleagues at the department; instead such knowledge can be transferred because the consultants help others to solve problems that occur at work (mean 6.3). New ideas and initiatives are not

strongly encouraged (mean 6.3) and learning is only weakly felt to be rewarded (mean 5.4), at least formally. The possibility of making a good career by hard and good work is felt to be neither strong, nor weak (mean 5.5). However, most respondents see themselves as loyal to their company and sacrifice some of their spare time to the company (mean 7.2). It can be concluded that there is no strong cultural support for learning and knowledge transfer when measuring perceptions among respondents.

6.3.5 Systems for training and learning

A further group of assertions in the questionnaire was about potential for learning, and these questions can be assigned to the type of enablers and facilitators known as systems for training and learning. The potential for learning is neither small nor large (see Table 6.9), all mean values being on the upper half of the scale. Most respondents want to learn more at work (mean 7.7) but they are cautious about change. The mean value 6.4 on the assertion "most changes are stimulating and provide new opportunities" indicates that many respondents are just slightly positive to change, regardless of age (explained by low correlation). Explanations may include the major changes in recent years due to the implementation of information technology and periods of declining demand for consultancy services.

Table 6.9 Assertions related to potential for learning. Nonparametric correlation (Kendall's t_b) of responses.

	Variables	1	2	3	4	5	6	Mean	SD
1	Age	1	-0.30**	-0.28**	-0.37**	-0.41**	0.14		
2	I want to learn more at work	-0.30**	1	0.44**	0.51**	0.49**	-0.12	7.6	1.4
3	I want to work more with new systems and methods at work	-0.28**	0.44**	1	0.35**	0.38**	-0.17	6.9	1.4
4	I want more responsibility at work	-0.37**	0.51**	0.35**	1	0.68**	-0.24**	6.6	1.4
5	I want to have a more qualified job content	-0.41**	0.49**	0.38**	0.68**	1	-0.19	6.6	1.5
6	Most of what I do contains a good mix of difficulties	0.14	-0.12	-0.17	-0.24**	-0.19	1	6.5	1.5

** Correlation is significant at the 0.01 level (2-tailed).
SD: Standard deviation.

However, attitudes to innovative work practices can be studied in a broader perspective. Other variables related to the potential for learning are willingness to work with new systems and methods (mean 6.9), the wish for more responsibility (mean 6.6) and the wish to have a more qualified work content (mean 6.6). There are high correlations significant at the 0.01 level between all these variables (see Table 6.9). Further analysis shows that these assertions vary with the age of the respondents, where younger employees are more flexible than older ones. However, the middle-aged respondents propose most of the new ideas and new ways of working. The age variable is

strongly and significantly correlated with the desire for more qualified content of work (-0.41) and the desire for more responsibility at work (-0.37) where the younger consultants feel more strongly than the older ones. This might be attributed to the fact that the older respondents are more satisfied and consider that they have sufficient responsibility and complexity.

Training and courses is one part of continuous learning that is emphasized by many authors as a mechanism to enable and facilitate knowledge transfer. The opportunity to attend courses is therefore to be identified as an enabling condition. Each respondent was asked in the questionnaire to list courses he or she had attended in 1996 and 1997. Answers show that courses in use of computer applications and administration dominate. Examples of courses that consultants had participated in during 1996 and 1997 are presented in Table 6.10 and 6.11. The courses and training programmes have been classified here according to three categories: (1) administrative and organizational, (2) computers and software, and (3) technology. Results from the interviews indicate that managers in the companies believe there remains a considerable need for hardware and software courses. It is common that courses belonging to the first two categories (except training in engineering software) are provided to employees in the whole consultant group and that technology courses are provided according to specialization. Unfortunately, the respondents think they do not learn much from internal courses (mean 4.6), although external courses are valued slightly higher (mean 5.7).

Table 6.10 Examples of available internal courses and training programmes for all four companies that consultants had participated in during 1996 and 1997.

Administrative and Organizational	Computer and Software	Technology
Project planning	Windows 95	Ground water chemistry
How to make a presentation	IT courses	Protection of water reservoirs
Leadership	WEB-editor	Environmental protection
Introduction to environmental issues	CAD, calculation program	Road design
Quality assurance	RoadCAD	Auditing and inspection
Construction law (for contractors)	Auto-CAD various versions	
Law (for consultants)	POINT and Auto-CAD	Follow-up Bygg 90
Project Management	CAD-P SPACE/MS SPACE	Technology meetings
Leadership training (management)	CAD	Geotechnology
Management development program	Skanska Software calculation	Fire protection design
Business for managers	Excel, MS Word, Word Perfect	Moisture protection design
Business for all	PX Control	Recycling station for buildings
Course for project managers	X-Steel	Modern steel construction
Business systems		Multistorey wood buildings
Administration		Noise

Table 6.11 Examples of available external courses and training programmes for all four companies that consultants had participated in during 1996 and 1997.

Administrative and Organizational	Computer and Software	Technology
Management training after individual wishes with relevance to work	Kordab	Inspection (3 days)
How to make a presentation	Novell	Sprinklers (1.5 days)
Project management	Autograph	Air condition and fire protection
AF AMA 98	RoadCAD 1-3	Sick buildings
Design management	Various PC courses	Courses from the National Road
Administration (financial issues)	Excel	Administration: Road design, safety at
Personnel administration	Windows 95/NT	site, work at site
Responsible for managing work	AutoCAD R14, Point 5	Swedish National Rail Administration
according to PBL (Planning and	MS Access 7.0	courses: Railway design
Building Act)	MS Project	Shelter specialist
	WSS-CAD 3	Restoration of concrete CBI
	System Administration	Foundations
	X-Steel	BBK 79, BSK 84

It is concluded that the willingness to work with new systems and methods, the wish for more responsibility, and the wish to have a more qualified work content correspond to averages on the upper half of the scale and that younger employees feel more strongly in these respects. Most consultants also want to learn more at work but it also seems that learning from training and courses is perceived to be rather low.

6.4 Summary

When transferring knowledge, it has been shown that internal methods rather than external were rated highly, with the exception of training and courses. Among internal methods, experience based and face-to-face communication are perceived as the most useful groups of methods for acquiring knowledge and information. It was difficult to identify a single more efficient method for distributing knowledge, but considering the possibility to make meaning of the distributed knowledge and information, it must be concluded that informal communicative methods involving colleagues at the department were prominent. When retrieving knowledge and information from organizational memory, the method perceived as most useful was relying on best practice from other projects.

Younger consultants are more mobile than older, both when it comes to changing jobs and changing company. This has implications not only for new recruitment, but also for finding employees to promote to more advanced functions. Most assertions about communication and monitoring of strategy in the questionnaire are related to organizational rewards, which were considered to be generally poor. However, from an improvement perspective, it is interesting to find that rewards for learning have a high correlation with encouraging new ideas, listening to suggestions and proposals, and good opportunities to make a career by doing a good job. There is a relative freedom of planning and solving problems when working. Among the job

characteristics, the tasks are perceived as challenging and varied, and the respondents use their competence in what they do. Routines described in the quality assurance system are not easy to use which correlates with low use and perception of low level of learning when using routines. Nor is there strong cultural support for learning and knowledge transfer according to the variables measured. Finally, it is concluded that the willingness to work with new systems and methods, the wish for more responsibility, and the wish to have a more qualified work content are on the upper half of the scale and that they are positively correlated to lower age. Most consultants also want to learn more at work but it seems that learning from training and learning from courses is rather poor.

Finally, the employees seem to be loyal to their companies, including the younger in the short time perspective (less than five years). However, reward systems do not appear to reward the employees for their loyalty or for their work sufficiently and opportunities for making a career are thought to be small. With this in mind, is it astonishing to see that many if not all employees experience high motivation, strong involvement, and are loyal enough to sacrifice their private life for work irrespective of age.

7 Knowledge management, the 2000 study

This chapter presents the results of the second study, carried out in early 2000. The same departments as in the first study, presented in the previous chapter, were surveyed with a questionnaire containing assertions regarding the knowledge transfer process and how it is enabled and facilitated. Results presented in this chapter show that tacit knowledge is now perceived as crucial and that interactive methods including face-to-face meetings are the preferred methods for knowledge transfer.

7.1 Relations between the background variables

In the analysis of background variables two issues are primarily worth noticing. The first two of the background variables were excluded from the analysis because of their high correlation (significant to the 0.01 level) with the age variable. Those variables were (a) the time a respondent had worked with the same kind of tasks (correlation coefficient 0.75) and (b) how long time the respondent had been employed in the present company (0.70). Second, the high correlation between high age and male gender (0.37) and the negative correlation (-0.34) between high age and high education (see Table 7.1) should be taken into account. The effects of gender and age are easy to explain, as the profession has traditionally been dominated by males and as younger people tend to have more formal education than older people, not least since the upper secondary school engineering programme (in Swedish: *gymnasieingenjör*) has been transformed into a university program.

Table 7.1 Nonparametric correlations of background variables (Kendall's t_b).

Background variable	Gender	Age	Function	Education	Primary task				
					Feasibility study	Conceptual design	Detailed design	Inspection	Admini-stration
Gender	1	0.37**	0.21*	-0.10	0.02	-0.09	0.08	-0.16	-0.03
Age	0.37**	1	0.14	-0.34**	-0.08	-0.09	-0.06	-0.25**	-0.19*
Function	0.21*	0.14	1	0.19*	-0.40**	-0.22*	0.46**	-0.01	-0.25**
Education	-0.01	-0.34**	0.19*	1	-0.19*	0.05	0.34**	0.19*	-0.03
Feasibility study	0.02	-0.08	-0.40**	-0.19*	1	0.07	-0.58**	0.00	0.16
Conceptual design	-0.09	-0.09	-0.22*	0.05	0.07	1	0.07	0.17	0.28**
Detailed design	0.08	-0.06	0.46**	0.34**	-0.58**	0.07	1	0.15	-0.10
Inspection	-0.16	-0.25**	-0.10	0.19*	0.00	0.17	0.15	1	0.12
Administration	-0.03	-0.19*	-0.25**	-0.03	0.16	0.28**	-0.10	0.12	1

** Correlation is significant at the .01 level (2-tailed).
* Correlation is significant at the .05 level (2-tailed).
Gender code: Females (= 0) and Males (= 1).
Frequency code for primary task: Often (= 1), Sometimes (= 2), and Never (= 3).

Just as could be expected, there is a correlation between having a more advanced function and doing feasibility studies. As feasibility studies usually require a great deal of knowledge, not only higher education or long experience was expected, but also higher age. The most common working

task, which was detailed design work, showed as expected from the theories of Maister (1982) a positive correlation with less advanced function but also with low education. Project managers and line managers do less detailed design work than feasibility studies and conceptual design work.

7.2 The knowledge transfer process

In this section the knowledge transfer process is discussed, according to the terminology outlined in the theoretical frame of reference, and as presented in the model of knowledge transfer in construction technical consultancy organizations in section 2.8. The aim is now to analyse what methods are used in the various sub-processes of knowledge transfer and thereby provide an understanding of how technical consultants actually engage in transfer.

7.2.1 Acquisition

Beginning with the sub-process of knowledge acquisition, activities or methods for acquiring knowledge have been surveyed. Table 7.2 shows the perceived usefulness of 27 methods of acquiring knowledge according to the final version of themes presented in the methodology chapter (see section 4.7.2). According to Dixon (1992) such methods can be categorized into methods for internal and external knowledge acquisition. The discussion below shows that proximity and degree of interactivity and oral communication influence perceived usefulness of the methods used.

Talking to colleagues at the department (mean 7.7 on the 10-degree scale) is perceived as the best method for acquiring knowledge (see Table 7.2). It is followed by using best practice from previous projects done by others in the company (mean 7.6), which is also a common method. However, best practice from projects done by others does not correlate significantly with access to lessons learned, as could have been expected, but it is significantly correlated (0.51) with reusing one's own experience as a best practice, with talking to colleagues in the same office (0.41), and with female gender (-0.38), which can be explained partly by covariation with age. This indicates at least that younger employees, such as most females are, use best practice from previous projects done by others to a larger extent than males. So far, the most useful internal methods for knowledge acquisition have been related to individual experience and to other individuals in the immediate surroundings. Acquiring knowledge tacitly held by individuals requires interactive methods that include oral communication or observation. With the exception of the method of acquiring knowledge from the library, more internal oral communicative methods will follow in declining importance (see Table 7.2). Communicating with people internally such as learning by helping colleagues (mean 6.8) and

learning by informal talks with colleagues at coffee breaks, etc. (mean 6.8) come next, and further strengthen the dominant position of interactive methods. Trying different tasks under planned supervision (mean 6.7) is another such method.

Table 7.2 Perceptions of how useful various methods for knowledge acquisition are.

Method	I/E	N	Mean	SD
I learn by talking to colleagues at my office/department	I	109	7.7	1.6
I use experience from previous projects that I have learned about from others as best practices when I participate in a new project	I	109	7.6	1.6
I use knowledge from the department library in my work	E	109	6.9	1.9
I learn by helping colleagues and others	I	108	6.8	1.6
I learn by informal talks with colleagues at my office/department: at coffee breaks, in the corridor and at lunch.	I	109	6.8	2.0
I learn in my work by trying different tasks and by planned supervision	I	109	6.7	1.8
I learn by reading professional journals and magazines	E	108	6.4	2.1
We use continuous improvement processes in order to acquire knowledge	I	109	6.3	1.8
I search the Internet for knowledge I need	E	108	6.2	2.4
I learn by reading books	E	109	6.1	2.0
I learn from interaction (credit and criticism) with users	E	108	5.9	1.8
I learn from interaction (credit and criticism) with clients	E	105	5.9	2.0
I learn from interaction (credit and criticism) with suppliers	E	108	5.8	2.3
I learn by attending internal conferences (*skråträffar, teknikområdesträffar*)	I	108	5.7	2.2
I learn by talking to colleagues in my company but outside my office/department	I	109	5.7	2.3
I learn by taking external courses	E	109	5.7	2.1
I learn by reading internal publications and lessons learned	I	109	5.6	2.2
I learn by taking internal courses	I	108	5.4	2.0
I believe quality audits are good opportunities for learning	I	106	5.2	2.1
I learn from interaction with other technical consultants	E	108	5.2	2.1
I search our intranet for knowledge I need	I	108	5.1	2.4
I have been involved in R&D projects where I have learned things useful for my work	I	109	5.1	2.5
I learn by participating in the weekly briefings at my department	I	107	5.0	2.3
I learn from interaction (credit and criticism) with architects	E	108	4.9	2.4
I learn by participating in staff mentoring arrangements	I	108	3.7	2.3
I learn by participating in discussion groups on the intranet (internal)	I	108	2.8	2.1
I learn by participating in discussion groups on the Internet (external)	E	109	2.7	2.0

I/E: (I) Internal acquisition and (E) external acquisition. N: Number of responses. SD: Standard deviation.

When it comes to knowledge that is acquired from other departments the usefulness is perceived to be lower. Talking to colleagues within the company but not in the same department or office (mean 5.7) falls in this category, as well as visiting internal conferences (mean 5.8). As can be seen in Table 7.3, correlations between perceived usefulness of internal methods are high, especially between informal discussions with colleagues and more formal discussions about specific questions (0.55) and the weekly briefings (0.30). Learning by attending internal conferences not only implies learning from lectures, but also from talking to colleagues from other departments and offices as those variables correlate significantly (0.44). Other internal interactive methods of less importance are quality audits (mean 5.2), R&D projects (mean 5.1), weekly briefings (mean 5.0), and finally staff mentoring arrangements (mean 3.7). Quality audits, R&D projects, briefings and staff mentoring arrangements are more occasional methods, which may to some extent explain why they have been seen as less useful.

Training by taking courses can be seen both as oral interactive communication and as a more passive method. Oral interactive communication does not

dominate among course participants but the degree of interactivity can be increased by the use of communicative elements such as group work, discussions and coffee breaks. Most courses are of a traditional kind, but web-based training is becoming a more frequent feature today, as described in section 5.2.1. Compared with external courses (mean 5.7), internal courses (mean 5.4) are perceived as slightly less useful as a method for acquiring knowledge.

Table 7.3 Knowledge acquisition methods where consultants communicate directly. Nonparametric correlations (Kendall's t_b).

No.	Method	2.8	2.9	2.10	2.11	2.12	2.13	2.14	2.15	2.16	2.17	2.18
2.8	I learn by attending internal conferences (skråträffar, teknikområdesträffar)	1	0.35**	0.22**	0.11	0.17*	0.42**	0.35**	0.34**	0.24**	0.09	0.17*
2.9	I learn by participating in the weekly briefings at my department	0.35**	1	0.23**	0.19*	0.30**	0.18*	0.17*	0.14	0.18*	0.04	0.21**
2.10	I learn by participating in staff mentoring arrangements	0.22**	0.23**	1	-0.03	-0.04	-0.05	0.08	0.13	0.25**	0.20**	0.19**
2.11	I learn by talking to colleagues at my office/department	0.11	0.19*	-0.03	1	0.55**	0.22**	0.08	0.09	0.05	-0.03	0.15*
2.12	I learn by informal talks with colleagues at my office/department: at coffee breaks, in the corridor and at lunch.	0.17*	0.30**	-0.04	0.55**	1	0.35**	0.20**	0.24**	0.09	0.01	0.20**
2.13	I learn by talking to colleagues in my company but outside my office/department	0.42**	0.18*	-0.05	0.22**	0.35**	1	0.43**	0.45**	0.33**	0.14	0.24**
2.14	I learn from interaction (credit and criticism) with clients	0.35**	0.17*	0.08	0.08	0.20**	0.43**	1	0.77**	0.30**	0.25**	0.28**
2.15	I learn from interaction (credit and criticism) with users	0.34**	0.14	0.13	0.09	0.24**	0.45**	0.77**	1	0.32**	0.23**	0.29**
2.16	I learn from interaction with other technical consultants	0.24**	0.18*	0.25**	0.05	0.09	0.33**	0.30**	0.32**	1	0.26**	0.36**
2.17	I learn from interaction (credit and criticism) with suppliers	0.09	0.04	0.20**	-0.03	0.01	0.14	0.25**	0.23**	0.26**	1	0.33**
2.18	I learn from interaction (credit and criticism) with architects	0.17*	0.21**	0.19**	0.15*	0.20**	0.24**	0.28**	0.29**	0.36**	0.33**	1

** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).

A second group of internal methods less highly valued is those where the consultant searches for knowledge without direct communication or interaction with other individuals. Internal publications and lessons learned (mean 5.6) as well as discussion groups on intranets (mean 2.8) fall in this category. It can be said of internal methods that proximity is preferred when choosing method for acquiring knowledge within the company. Consultants prefer to find knowledge close to where they work and to talk with other people face to face. Reading coded and explicit knowledge from internal sources is less valued.

External methods can be assigned to almost the same categories as internal methods. However, non-communicative methods such as using the department library (mean 6.9), reading professional journals and magazines (mean 6.4), searching the Internet (mean 6.2) and reading books (mean 6.1) have the highest score of the external methods. These methods are examples of external sources the consultant can use without leaving the office or

making contact with other people. They are followed by more obviously communicative external methods such as learning from users (mean 5.9), clients (mean 5.9), suppliers (mean 5.8), other technical consultants (mean 5.2), and architects (mean 4.9). There are a few variations, depending on specialization (see discussion in section 2.2.1). Respondents working at a department specialized in building find learning from both architects and suppliers more valuable than respondents from departments specialized in civil engineering (see Table 7.4)[33].

Table 7.4 Perceptions of usefulness of external methods for knowledge acquisition related to building and civil engineering work.

Method	Specialization	N	Mean	SD
I learn from interaction (credit and criticism) with clients	Building	53	5.9	2.0
	Civ. eng.	52	5.8	2.1
	Total	105	5.8	2.0
I learn from interaction (credit and criticism) with users	Building	55	6.0	1.7
	Civ. eng.	53	5.8	2.0
	Total	108	5.9	1.8
I learn from interaction with other technical consultants	Building	54	5.3	1.9
	Civ. eng.	54	5.1	2.3
	Total	108	5.2	2.1
I learn from interaction (credit and criticism) with suppliers	Building	55	6.6	1.8
	Civ. eng.	53	5.0	2.4
	Total	108	5.8	2.3
I learn from interaction (credit and criticism) with architects	Building	55	5.8	1.9
	Civ. eng.	53	4.0	2.6
	Total	108	4.9	2.4

N: Number of responses. SD: Standard deviation.

Discussion groups on the Internet (mean 2.7) are perceived as being of little value, just as discussion groups on the intranet (mean 2.8). This negative assessment corresponds well with interviews and observations in the four companies, and as mentioned in section 5.2.2, there are not many discussion groups established or active. In spite of being an external source of knowledge, an Internet discussion group is accessible from the office, and may, owing to its wider availability, have a great potential for transferring knowledge.

The conclusion drawn here about physical distance, choice of method and its usefulness can now be refined further. The internal communication methods are followed by other methods with physical proximity such as acquiring knowledge from the department library, magazines and the Internet. Those, in turn, are followed by external communication methods and training. It can also be argued that colleagues in the same company, but at other offices, are

[33] According to the Kruskal-Wallis test of ranks there are significant differences between the two groups for those two variables. It should also be mentioned that all correlations between learning from various external actors are rather high and significant to the 0.01 level (see Table 7.3), especially in the case of learning from interaction with clients and users.

seen as less useful than users, clients and suppliers whom the consultants interact with daily in projects. It can therefore be concluded that physical distance to the source of knowledge is important for the perceived usefulness of methods for knowledge acquisition. For each group, informality is preferred before formality.

7.2.2 Distribution and making meaning

The next two sub-processes of knowledge transfer are knowledge distribution and making meaning. Twelve of the methods are the same as for internal knowledge acquisition because there is no sharp demarcation line between when the three sub-processes are performed. Just as for knowledge acquisition, informal methods for distributing knowledge have been perceived as most useful. Talking to colleagues at the office (mean 7.7), helping colleagues and others (mean 6.8) and informal discussions with colleagues at coffee breaks or at lunch (mean 6.8) are perceived as the most important methods (se Table 7.5). Many methods of internal knowledge acquisition give rise to an almost immediate distribution of knowledge. However, in terms of both distribution and making meaning, there is a need for reflection on and analysis of distributed knowledge. Such reflection and analysis is facilitated by dialogue between sender and receiver or other experienced individuals. The opportunity to reflect in a group may be one explanation why interactive methods including oral communication have the highest mean values.

Table 7.5 Perceived usefulness of methods related to distributing and making meaning.

Method	N	Mean	SD
I learn by talking to colleagues at my office/department	109	7.7	1.6
I learn by helping colleagues and others	108	6.8	1.6
I learn by informal talks with colleagues at my office/department: at coffee breaks, in the corridor and at lunch	109	6.8	2.0
I learn in my work by trying different tasks and by planned supervision	109	6.7	1.8
We try to encourage open dialogues in order to acquire knowledge	107	6.6	1.8
We have knowledge communities that help each other.	108	6.3	2.0
I learn by attending internal conferences (*skråträffar, teknikområdesträffar*)	108	5.8	2.2
I learn by talking to colleagues in my company but outside my office/department	109	5.7	2.3
I learn by reading internal publications and lessons learned	109	5.6	2.2
Our staff are encouraged to talk about their own work and the business in general	109	5.5	2.1
I learn by taking internal courses	108	5.4	2.0
We are encouraged to participate in knowledge communities we choose ourselves	109	5.2	2.2
I believe quality audits are good opportunities for learning	106	5.2	2.1
We try to encourage people to question assumptions in order to create knowledge	107	5.2	2.2
I learn by participating in the weekly briefings at my department	107	5.0	2.3
The company has a corporate story book	103	4.8	2.6
We interview new employees in order to learn from their unique knowledge when they start to work at our company	107	4.7	2.1
We encourage job rotation and working with different tasks in different projects in order to acquire knowledge	109	4.2	2.0
I learn by participating in staff mentoring arrangements	108	3.7	2.3
I learn by participating in discussion groups on the intranet (internal)	108	2.8	2.1

N: Number of responses. SD: Standard deviation.

The informal methods are followed by more formal ones such as learning by trying different tasks or planned supervision (mean 6.7), formal as well as

informal networks such as knowledge communities (mean 6.3) followed by internal conferences (mean 5.8) and job rotation (mean 4.3). The low mean value for job rotation can perhaps be explained by few such initiatives in the four companies (as appears from the interviews in section 5.2.1). Individual written communication such as encouraging reading (mean 5.6) and especially reading internal publications and lessons learned (mean 5.6) are not perceived as particularly valuable for knowledge distribution. Three methods are used on purpose to facilitate and increase the dialogue element. Encouraging knowledge communities (mean 5.2) and talking about the business (mean 5.5) are among them. The third is to encourage employees to question assumptions (mean 5.2), something that facilitates critical reflection and interpretation. With the exception of three informal methods including verbal face-to-face communication, all methods presented are in the middle interval of the scale, indicating that they are used to some extent but not much.

Other methods include cultural knowledge vehicles such as stories and myths, which are primarily unintentional, but nevertheless can be distributed intentionally in company story books (mean 4.8). Examples of such books are J&W (1988) presented at the fiftieth anniversary of the company and at SCC, also for the fiftieth anniversary (Lindmarker, 1997). Briefings such as when interviewing new members of staff (mean 4.7) and minimizing knowledge erosion from employees who end their job or retire (mean 3.8) are unusual and considered to be of minor importance. With an employee turnover as high as around 15 per cent in mind (e.g. for SWECO in 1999 as high as 16 per cent, SWECO, 2000) this can be thought to be contrary to expectations. All methods presented in this section have received mean values that indicate that the methods are not used fully.

When acquiring, distributing and retrieving knowledge it is important to have access to where it is stored. In the questionnaire (see Table 7.6), the consultants answered that they often have access to knowledge holders both inside and outside the company (mean 7.0). When it comes to geographically dispersed knowledge, perceived as being integrated into the corporate memory, the rank is lower (mean 6.0). Lessons learned are not believed to be easily accessed (mean 5.1). This difficulty of access can be explained by what is obvious from Table 7.7, where best practice and other knowledge from similar projects, which can be said to include lessons learned, are stored in the heads of people, and only to a limited extent as explicit knowledge.

Table 7.6 Perceptions of access to knowledge.

Variable	N	Mean	SD
I have access to knowledge holders both inside and outside the company	109	7.0	2.1
Geographically dispersed knowledge is integrated in the corporate memory and made available within the company	107	6.0	2.2
Lessons learned from different projects are made easily accessible to all in the company	108	5.1	2.1

N: Number of responses. SD: Standard deviation.

The most useful methods for distributing and making meaning of knowledge are informal methods where people meet and talk face-to-face. It is not only that direct communication is the best example of rich media, which allows for much knowledge or information to be distributed rapidly, it also allows reflection together with the sender, thereby enabling the transfer sub-process of making meaning. Furthermore, the intradepartmental methods were preferred before extradepartmental methods.

7.2.3 Organizational memory

As could be expected when studying organizational memory, respondents perceived that most knowledge is stored in the heads of people (see Table 7.7). In Chapter 2 it was argued that all knowledge always entails a knower and that knowledge per definition has to be stored within the heads of people. However, it was also found that knowledge in an extended sense can be embedded in procedures, technical and administrative systems, including documents. Furthermore, internal memory has been categorized into intentional and unintentional storage.

Among the types of intentional storage, electronic records are found here to be the most common medium except for knowledge of similar projects, which is perceived to be more frequently stored in a combination of paper and electronic records. Artificial intelligence applications such as expert systems seem unimportant here for all categories of knowledge.

Again following Dixon's (1992) terminology, theories of action (practices of work) is according to the questionnaire responses the most common type of storage, followed by ecology (the physical structure of the work environment and physical workplace) and structures, if data in Table 7.7 are interpreted in her terms. Organizational culture, including myths, stories, language and symbols has a low percentage. This is contradictory to what most of the literature says about the importance of organizational culture as a carrier of knowledge. However, it should be kept in mind that writers on corporate culture argue that it is difficult for members of a culture to observe what their culture entails. This may explain why so few consultants perceive knowledge as being stored in their culture. Formal processes account for the lowest percentages. This can perhaps be explained by the absence of formal technical

processes discussed in Chapter 5 and the many local adaptations of the project management process discussed in section 5.1.3. Instead the lack of reliance on knowledge storage in processes seems to confirm what Brown and Duguid (2000) say about task performance in less linear and less clearly defined processes in organizations. They conclude that such organizations tend to use practice more than processes, and practice is stored within people.

Table 7.7 Percentage of total number of responding consultants' perceptions of how various knowledge categories are believed to be stored. Knowledge belonging to a single category can be stored in several storage media (N = 109).

Knowledge category	People	Theories of action	Ecology	Structure	Culture	Formal processes	Core competence	Policies	Paper records	Electronic records	Expert systems	External	Don't know
Knowledge maps - who knows what	55	14	9	15	4	4	8	3	17	29	12	2	7
Methods and processes	40	41	6	10	0	17	5	5	20	17	6	2	5
Best practice and know-how	43	22	12	6	5	6	6	4	15	10	6	2	8
Knowledge from similar projects	64	28	9	5	3	4	8	0	35	23	6	0	1
Internal organization and management information and knowledge	11	6	6	25	6	0	0	2	21	51	12	2	2
Own services	21	7	4	23	11	2	14	14	18	28	8	2	9
Regulatory environment	34	18	17	7	2	10	6	5	33	33	8	6	3
Emerging trends	30	3	17	5	5	1	5	4	10	10	4	21	20
Competitors	50	3	17	6	8	1	1	1	10	4	1	22	12
Customers	59	10	16	8	6	2	4	5	9	5	2	12	6
Own markets	51	6	18	6	5	1	3	5	8	8	3	17	8

External storage is perceived as low except for knowledge about competitors and emerging trends, where about one fifth of the consultants stated that such knowledge was stored externally. Knowledge belonging to the categories of emerging trends and competitors are also consistently what most consultants find difficult to locate. Knowledge and information about the regulatory environment is to a large extent stored in electronic records and also to an ever increasing extent stored externally and available on the Internet.

The consultants were asked not only where they perceived knowledge to be stored, but also at what organizational level the eleven categories of knowledge were disseminated and shared (see Table 7.8). Internal organization and management information and knowledge was perceived as the most efficiently disseminated category of information and knowledge. The second most disseminated category was knowledge about the various external services provided by the company. Comparing mean values from the four companies it is striking to see how similarly the respondents answered. According to the Kruskal-Wallis test of variance with ranks[34], there are only

[34] The method for performing the Kruskal-Wallis test of variance with ranks is described in section 4.5.1.

three significant differences among the eleven knowledge categories. The first difference concerns knowledge about the internal organization and management information. Respondents in three of the companies stated that this knowledge was shared at department and division levels, while one company diverged by their respondents stating that it was shared at company and division levels. The other two knowledge categories where differences between companies can be observed are methods and processes as well as best practice and know-how. Those differences are particularly large between the departments studied in the two companies, one department specialized in structural engineering and one department providing building services engineering. This means that the first company organized according to technologies is probably better at sharing knowledge about technology and processes at higher levels in the company than the second, geographically organized company[35]. Mean values for the first company organized according to technology (mean 2.1 for methods and processes and 2.7 for best-practice and know-how) indicate that knowledge is shared at division level and mean values for the second company organized according to geography (mean 2.9 and 3.2) indicate that knowledge is shared at department level. It could have been expected that the situation should be reversed in the favour of the geographically organized company when analysing knowledge about (1) the market, (2) customers and (3) competitors. However, there was no significant difference that could confirm that these knowledge categories were shared more at higher hierarchical levels in the geographically organized company than in the technologically organized company.

Table 7.8 Frequency for the highest organizational level where categories of knowledge are perceived as being disseminated and shared.

Knowledge category	Organizational level				N	Mean organizational level	SD
	Company (= 1)	Division (= 2)	Department (= 3)	Not shared (= 4)			
Internal organization and management information and knowledge	84	12	11	2	109	1.4	0.7
Own services mix	58	30	14	5	107	1.7	0.9
Regulatory environment	39	39	28	3	109	2.0	0.9
Knowledge maps - who knows what	28	35	36	9	108	2.2	0.9
Emerging trends	15	48	28	17	108	2.4	0.9
Own markets	12	41	43	12	108	2.5	0.8
Knowledge from similar projects	6	43	51	6	106	2.5	0.7
Methods and processes	8	40	42	16	106	2.6	0.8
Best practice and know-how	8	32	52	17	109	2.7	0.8
Customers (what they want, local standards, whom they work with)	5	30	48	26	109	2.9	0.8
Competitors (what they know and do)	4	35	37	32	108	2.9	0.9

N: Number of responses. SD: Standard deviation.

[35] Mean values and the Kruskal-Wallis' test also showed a difference when comparing answers in the two categories of knowledge about methods and processes and about best practice and know-how. Using the Mann-Whitney test to compare the two companies, significant (0.01 level) differences were found.

From the interviews with managers it has become clear that the companies often strive to tender for all kinds of consultancy services the client may need for a project. Doing so requires knowledge about services of other divisions and about what they know. An organizational example of how this ability can be strengthened is the transformation of one of the companies into a geographical structure where all regions include almost all specializations and services of the company. The interviewed department manager stated that it is easier to combine and offer various technical specializations after the transformation into a geographically organized company. However, no evidence was found in the statistical analysis that knowledge about the service mix of the own company would be more shared at company level than at the department level, regardless of if the company was organized according to geography or technology. At the same time it is more difficult to transfer best practice and experience from assignments to colleagues with the same specialization but in other geographical areas, as discussed for the building consultants above. In contrast to this company and their regional organization, another company reorganized into what can be seen as mainly a technology based organization. According to the interviewed department manager in this company, this transformation was done to strengthen expertise, increase cooperation within the various specializations and to support creation and transfer of technical knowledge. As regards knowledge about methods and processes, about best practice and know-how, such knowledge is more widely shared in the technology organization, differences in mean value being almost as large as for the two companies discussed in the previous section.

Interviews show that knowledge maps were in little use at the time of the study. As can be seen in Table 7.8, knowledge about who knows what is primarily disseminated at department and division level. The high standard deviation also indicates that the respondents do not agree about the organizational level for knowledge mapping. This can be explained by the fact that none of the companies had a fully implemented IT tool in use for knowledge mapping. KM's KnowMan seemed to be the most developed system but it was new at the time of the study and not yet in full use. The other three companies had at least electronically stored CVs that could be used, in many cases, in combination with project databases and reference databases, but it was impossible to get fast and complete answers from them. As could be concluded from Table 7.7, more than half the consultants perceive that "who knows what" knowledge was stored primarily in the heads of people, and next, but only by 29 per cent of the respondents, in electronic records.

Knowledge about the market and customers was perceived as being local and primarily shared at department level; the same is true of knowledge about

competitors (see Table 7.8). These observations imply that the market has a local character.

In rating how crucial to the business the same eleven knowledge categories are, respondents prioritized knowledge about the market (mean 7.0) (see Table 7.9). Knowledge from similar kinds of projects (mean 7.0) is valued as just as important as knowledge about the market, but with lower standard deviation. These two knowledge categories are followed closely in rank by customer knowledge (mean 6.9).

Table 7.9 Perceptions of how crucial different knowledge categories are to the organization in order to produce what the customer wants.

Knowledge category	N	Mean	SD
Own markets	107	7.0	2.2
Knowledge from similar projects	105	7.0	1.9
Customers (what they want, local standards, whom they work with)	106	6.9	2.3
Regulatory environment	107	6.9	2.3
Best practice and know-how	105	6.4	1.7
Methods and processes	105	6.3	1.7
Emerging trends	107	6.2	2.9
Own services mix	106	6.1	1.9
Knowledge maps - who knows what	107	6.1	1.8
Competitors (what they know and do)	106	5.8	2.0
Internal organization and management information and knowledge	106	5.4	2.3

N: Number of responses. SD: Standard deviation.

Best practices and know-how (mean 6.4) and methods and processes (mean 6.3) are not valued as highly, although they contain experience from previous projects (see Table 7.9). It can be thought that they are not specific enough for the particular project they are intended to be used in. Nevertheless, when acquiring knowledge, experience of others and previous projects were perceived as the most useful methods of acquisition. As best practice and know-how as well as similar project knowledge are perceived to be stored mainly in the heads of people they are tacit to a large extent, just as knowledge about competitors and customers.

Internal organization and management information is ranked as least crucial in Table 7.9. This category of knowledge is perceived as being stored mainly in electronic records, and it is perceived also as the most disseminated category of knowledge in the survey. The high availability of knowledge belonging to this category may perhaps explain why it is perceived as less crucial. It may simply be taken for granted.

According to the theoretical frame of reference, tacit knowledge needs to be transferred by a socialization process. It can also be converted to explicit knowledge through externalization, followed by distribution and making meaning before it can be internalized and used by others. Such processes call for interaction and face-to-face dialogue between people. With the exception of knowledge about the regulatory environment, the more crucial knowledge

categories can be claimed to consist largely of tacit knowledge. Internal communication methods are preferred for knowledge acquisition, and informal methods where people meet and talk face-to-face are preferred also for knowledge distribution and interpretation. In both cases the methods can be parts of a knowledge transfer process where tacit knowledge is transferred.

7.2.4 Retrieval

Reuse of one's own experience is perceived as the most useful method (mean 8.3, see Table 7.10) for retrieving knowledge. Most such knowledge is tacit and stored in the memory of the individual, where it obviously is easy accessible. Experience is so deeply rooted in the individual mental models that it is automatically retrieved when needed. This retrieval method is followed in rank by talking to colleagues at the office (mean 7.7). According to the interviews in the first study (1997-98), talking to colleagues in the corridor was the first thing respondents would do if there was something they did not know but wanted to know. Together with other methods where people communicate, it belongs to the category of controlled retrieval. Compared with other methods a retrieval, the standard deviations of the three most used methods are lower, implying a high degree of consensus. Using experience from projects done by others (mean 7.6), retrieving information and knowledge from informal discussions in the corridor or at the coffee break (mean 6.8), and talking to colleagues outside the department (mean 5.7) are also controlled methods of retrieval. Among the methods mentioned above, the likelihood of retrieving knowledge from a single individual or from a group of individuals may be different. Retrieving knowledge from colleagues at other departments is an example of a method where you often use the telephone and call someone considered an expert, someone who has recently done the same thing, or somebody else from a personal contact network. Most such contacts are between two individuals but there might be occasions where more than two employees meet.

Table 7.10 Perceptions of how useful various methods for retrieval are.

Method	Method	Mean	SD
I use my experience from previous projects as a best practice when I participate in a new project	T	8.3	1.4
I learn by talking to colleagues at my office/department	I/G	7.7	1.6
I use experience from previous projects that I have learned about from others as best practices when I participate in a new project	G	7.6	1.6
I learn by informal talks with colleagues at my office/department: at coffee breaks, in the corridor and at lunch	I/G	6.8	2.0
I learn by talking to colleagues in my company but outside my office/department	I/G	5.7	2.3
I search our intranet for knowledge I need	S	5.1	2.4
I learn from using routines and checklists in my company's quality assurance system	S	4.9	2.3
I learn by participating in discussion groups on the intranet (internal)	G	2.8	2.1

Controlled retrieval: (I) Individual and (G) Groups of individuals. Automatic retrieval: (S) Structures and (T) Individual and tacit knowledge. SD: Standard deviation.

Some knowledge is stored in the structures of the company. Knowledge in databases available on the intranet (mean 5.1) and the quality assurance system (mean 4.9) are examples of such knowledge. It is, however, difficult to say that they can be automatically retrieved. The employees know they exist, but they have to retrieve that specific knowledge on purpose. Some knowledge included in the quality assurance system such as the project management process can be stored in the deeper structures of organizational memory and as a consequence be retrieved automatically.

7.3 Enabling conditions and facilitating activities

The questionnaire contained eight themes related to enabling conditions and facilitating activities, which will be presented in sections 7.3.1-7.3.3. First, personal characteristics and job characteristics of the technical consultants will be analysed in section 7.3.1, followed by section 7.3.2 for organizational enablers and facilitators, and section 7.3.3 for the five themes related to technological enablers. In contrast to the analysis of the first study (1997-98) in Chapter 6 personal characteristics and job characteristics are analysed separately. Personal characteristics are related to the individuals and how they perform their work and their wishes for future work. Job characteristics are related to the specific kinds of tasks performed by the individuals. Depending on the character of the task, a variation in answers can be expected. The enabling conditions and facilitating activities that remain are independent of the individual consultant or the specific tasks.

7.3.1 Personal characteristics and job characteristics

The questionnaire included thirteen personal characteristics that can enable learning and knowledge transfer. Three characteristics have been sorted by mean value in Table 7.11. Values for several characteristics show that the potential for learning is high. Willingness to learn more at work attains a mean value of 9.0. Consultants also want to work with new systems and methods (mean 7.8); they find changes stimulating (mean 7.8); they feel motivated (mean 7.8), and they want to have a more qualified job content (mean 7.6). When working, they often find that they can contribute to solving problems that occur at work (mean 7.6); they are often loyal to their companies and give up their private life for work (mean 7.4), and find themselves involved in work while also doing more than expected (mean 7.1). Participating in fora such as trade associations are not found to be interesting or particularly useful for knowledge transfer.

The personal characteristics correlate with background variables such as function, education and two types of major task. Not surprisingly, age is

negatively correlated to the wish to work with new systems (-0.28) and with the wish for more responsibility (-0.22). Furthermore, function is significantly correlated at the 0.01 level with contribution to solving problems (0.25), a meaningful and motivating work (0.27), often doing more than expected (0.29, helping others to solve problems, and with taking new initiatives in work (0.30). A high educational level is significantly correlated to the wish of learning more in work (0.20) and the wish to work more with new systems and methods. Respondents who work with conceptual design as their major task perceive more loyalty and give up private life for work (-0.26) and they also take more initiatives at work (-0.22) than their colleagues. Finally those who mainly administrate (most department managers) find their jobs stimulating (-0.26), they give up private life for work (-0.26), and more often help others in work (-0.29) than their colleagues do.

7.11 Personal characteristics and job characteristics at technical consultants

Characteristic	N	Mean	SD
Personal characteristics related to potential for organizing knowledge transfer			
I want to learn more at work	108	9.0	1.1
I want to work with new systems and methods	108	7.8	1.5
Most changes are stimulating and provide new opportunities	108	7.8	1.5
My work is meaningful and I feel motivated	109	7.8	1.4
I want to have a more qualified job content	107	7.6	1.6
I contribute to solving most problems that occur in my job	109	7.6	1.3
I'm loyal to my company and sacrifice my private life for my work	108	7.4	1.9
I want more responsibility at work	108	7.3	1.7
I get a lot done at work	109	7.1	1.3
I'm involved in my work and often do more than expected	109	7.1	1.5
I often help others to solve problems that occur at work	109	7.0	1.8
I often take new initiatives in my work	108	6.8	1.8
I'm interested in trade associations related to my work	109	5.2	2.3
Job characteristics related to organizing work			
I use much of my knowledge in my work	109	7.9	1.4
I plan my work	108	7.6	1.5
My work contains elements of new demands and challenges	109	7.3	1.3
Much of my work is routine	109	5.0	1.5

N: Number of responses. SD: Standard deviation.

There are also four job characteristics related to learning and knowledge transfer (see Table 7.11). Correlation analysis for these indicates that being in a more advanced function in the organization correlates significantly at the 0.01 level with using knowledge at work (0.25) and that work contains new demands and challenges (0.21). Consultants with a higher educational level perceive that they do less routine work (-0.28) and those who have conceptual design as their main task plan their work to a larger extent than their colleagues (-0.21). Although the correlations are significant, they are low. When analysing the mean values of the job characteristics, the consultants responded that they often use much of their knowledge at work (mean 7.9). They also plan their work often (mean 7.6), which should imply that they are involved in learning processes, especially if they get feedback. Having a job that is challenging and contains new elements promotes learning. The respondents often answered "yes, often" to that particular question (mean

7.3). Correspondingly, they gave lower scores on the question whether they find much of their work to be routine (mean 5.0).

7.3.2 Organizational enablers and facilitators

Organizational conditions that enable and facilitate learning and knowledge transfer were discussed in section 2.7.1. The questionnaire surveyed the attitudes of the consultants to assertions related to various types of enabling conditions and facilitating activities (see Table 7.12). There are two variables related primarily to organizational structure: first that the consultants are, to a large extent, given access to knowledge holders (mean 7.0), secondly that they are often given the opportunity to learn things important for work (mean 5.2).

Table 7.12 Assertion related to the five types of organizational enablers and facilitators (E/F). Answers indicate to what extent respondents agreed with the assertions.

Assertion	E/F	N	Mean	SD
We help and support each other at work	C	109	7.5	1.5
Employees take responsibility for their own learning	T	109	7.4	1.7
I'm expected to share knowledge and experience with others at work	P	109	7.4	2.0
I have access to knowledge holders both inside and outside the company	O	109	7.0	2.0
A climate of openness and trust permeates the organization	C	108	6.4	2.0
There are good opportunities to make a career by doing a good job	S	108	6.1	2.2
We encourage initiatives and experimenting in order to acquire knowledge	C	108	6.1	2.1
The organization encourages and facilitates knowledge sharing	S	109	6.1	1.9
Flexibility and desire to innovate drive the learning process	T	109	6.1	1.8
Geographically dispersed knowledge is integrated in the corporate memory and made available within the company	P	107	6.0	2.2
We encourage reading in order to acquire knowledge	S	109	5.6	2.0
We are rewarded for learning at my job	S	108	5.2	2.2
There are opportunities to learn things important to my work	O	109	5.2	2.0
Lessons learned from different projects are made easily accessible to all in the company	P	108	5.1	2.1
The company has a corporate story book	C	103	4.8	2.6
Our training budget is adequate or better than adequate	S	108	4.7	2.2
We send people to conferences in order to acquire knowledge	T	108	4.3	2.1
The company has a well implemented suggestion system	P	106	3.9	1.9
The company has a way of minimizing knowledge erosion	P	109	3.8	2.0

(E/F) Type of enabler/facilitator: (O) Organizational structure, (S) Communication and the monitoring of strategy, (P) Process, (C) Culture, (T) Systems for training and learning. N: Number of responses. SD: Standard deviation.

Five variables with high positive correlations to each other are related to communication and the monitoring of strategy. The highest ranked of these four variables is the possibility to make a career by doing a good job (mean 6.1). Just as high in rank is whether the organization encourages and supports knowledge sharing (mean 6.1) followed by encouraging reading (mean 5.6). However, since the mean values are low it can be concluded that respondents perceive that the organization neither supports learning nor works for it. Neither are the employees convinced that they are rewarded for their learning (mean 5.2) nor does the company clearly have an adequate budget for training (mean 4.7).

The third group of assertions refers mostly to managing knowledge as a process and implies a rational perspective on learning and knowledge transfer.

The assertion that comes closest to consensus in this group is that employees often are expected to share knowledge (mean 7.4). Four variables refer to whether geographically dispersed knowledge is integrated in the organizational memory and made available. The low mean value for the explicit assertion about integrating geographically dispersed knowledge in the corporate memory (mean 6.0) combined with an even lower mean for making lessons learned available (mean 5.1) indicate that the well known problem of managing experience still exists within the departments surveyed. Suggestion systems can also be referred to as a method for making geographically dispersed knowledge available to the organization. It is revealing to see that the perception of the efficiency of suggestion systems is low (mean 3.9). The mean value could have been expected to be higher, as all quality assurance systems include non-conformance reports, on the basis of which many suggestions can be made. Far from contradicting the interviews, respondents perceive that there was little in the way of a system available for preventing knowledge erosion (mean 3.8). As was discussed in Chapter 5, there seems to be no interview or knowledge documentation when employees retire or leave the companies for other reasons.

Culturally related variables have higher means. Helping and supporting each other (mean 7.5) facilitates learning and knowledge transfer. Openness (mean 6.4) and encouraging experimenting (mean 6.1) come next. The presence or effect of a corporate story book comes further down the scale (mean 4.8) and it is obviously not seen as an important enabler for learning and knowledge transfer.

Systems for training and learning are the last type. “Flexibility and desire to innovate drive the learning process” receives a low mean value (6.1), as should be expected from the review of technology change in Chapter 1. Taking responsibility for one’s own learning seems to be usual as the mean value (7.4) is well on the upper half of the scale.

Table 7.13 How employees perceive the ambition of seven issues related to current knowledge management initiatives.

Issue	N	Mean	SD
Establishing a reputation on the market as a best practice company	107	7.6	2.2
Standardization of knowledge in the form of procedures/protocol	107	6.6	1.6
Generation of new knowledge inside the organization	108	6.3	1.9
Facilitation of the reuse of knowledge about operations	107	6.1	1.7
Acquisition of new knowledge from external sources	105	5.7	1.8
Transforming individual knowledge into collective (organizational) knowledge	107	5.4	1.8
Combination of customer related knowledge and internal know -how	107	5.3	1.7

N: Number of responses. SD: Standard deviation.

When valuing current knowledge management initiatives, the consultants were asked to reveal the perceived ambition for seven issues (see Table 7.13). The ambition in trying to establish a reputation on the market as a best practice

company (mean 7.6) scores highest. It is followed by standardization of knowledge by embedding it into procedures and protocols. The ambition to facilitate reuse of knowledge about specific operations (mean 6.1) is not perceived as high, although the use of experience from previous projects learned from others was among the most frequently used methods for transferring knowledge. Finally, the ambition for service development through combining customer knowledge and internal know-how is surprisingly low (mean 5.3).

7.3.3 Technological enablers

Intranets are among the new process tools available today. It can be claimed that an intranet is not a tool in itself, but rather a shell that hosts various process support tools. The survey therefore aimed to find out what services on the intranet are the most frequently used. There are, however, also several support tools that do not count as intranet solutions. The use of such other tools has been surveyed together with the perceived importance of various tools. Finally, the survey contains variables that express the respondents' attitudes toward experience of IT.

Intranets

Not surprisingly, internal services such as administration are the most frequently used sources on the intranets (see Table 7.14). Document management with access by intranet and the use of knowledge derived from documents from projects in progress follow in order. It can be noted that most of the services listed in Table 7.14 are used only to a small extent, the first two excepted. As discussed in sections 5.2.1 and 5.2.2 where interview responses regarding formal methods and processes were reported, best practice and knowledge maps hardly exist. There are a few exceptions such as recently started knowledge maps and the formal project management process described in the quality assurance system for each company.

Table 7.14 The most frequently used services from the four intranets.

Intranet service	N	Mean	SD
Internal services such as administration	108	6.6	3.4
Document management	108	5.4	3.2
Knowledge from projects in progress	107	3.8	2.4
Knowledge maps - who knows what	108	3.7	2.2
Knowledge from finished projects	107	3.6	2.1
Methods and processes	108	3.2	2.1
Best practice and know-how	108	3.0	1.8
Own markets	108	2.9	2.0
Customers (what they want, local standards, whom they work with)	108	2.6	1.8
Competitors (what they know and do)	108	2.3	1.6

N: Number of responses. SD: Standard deviation.

Services providing knowledge about competitors, customers and the market are hardly used at all. This can be explained by their low availability on intranets. According to Table 7.7, such knowledge is believed to be stored principally in the heads of people and externally, for instance on the Internet. The low mean values in Table 7.14 indicate that the consultants did not find their intranets particularly useful.

Technological process support tools and frequency of use

The consultants were also asked to estimate how often various communication tools and other process support tools were used (see Table 7.15). Not surprisingly, the telephone (mean 8.6) was ranked highest, closely followed by e-mail (mean 8.4). According to the interviews with IT experts, great efforts have been put into creating standardized IT platforms since 1998. The use of standardized platforms seems to be common (mean 7.5). It is often found that the tools included in these standardized platforms support communication. The use of the Internet (mean 6.4) and intranet (mean 6.5) were just as high as the use of facsimile (mean 6.5) and higher than the use of traditional mail (mean 5.9). Traditional mail is not a technological tool if IT is interpreted narrowly, but it is a medium for knowledge transfer. Other modern media such as groupware, discussion lists, video and web conferencing were very seldom used. As described in section 5.2.2, not all tools were available to all consultants. Perhaps there is no clear need for media supporting virtual meetings, given the way these organizations operate today. The attitudes towards traditional telephone conferences indicate that they are also used only seldom.

Table 7.15 Perceptions of how often technological support tools for managing knowledge are used.

Technological support tool	Many times a day (= 10-9)	Often. Daily (= 8-7)	A few times a week (= 6-5)	A few times a month (= 4-3)	Almost never (= 2-1)	N	Mean	SD
Telephone	71	27	8	2	1	109	8.6	1.7
E-mail	58	36	13	2	0	109	8.4	1.6
Standardized IT platforms (hw/sw)	57	20	9	7	14	107	7.5	3.0
CAD software	49	17	9	10	24	109	6.7	3.5
Facsimile	31	38	37	11	6	109	6.5	2.1
Intranet	22	36	33	11	10	109	6.5	2.4
Internet (WWW)	20	36	33	11	10	109	6.4	2.3
Document management system	33	26	15	9	26	109	6.1	3.2
Mail (traditional)	8	36	35	23	7	109	5.9	2.0
Software for technical estimations	16	27	29	21	16	109	5.7	2.6
Project management software	2	5	22	34	46	109	3.3	2.1
Knowledge maps - who knows what	0	4	13	40	52	109	2.9	1.8
Decision support	2	3	12	24	65	106	2.6	2.0
Telephone conference	0	0	6	36	67	109	2.3	1.5
Groupware	1	3	8	14	83	109	2.3	1.8
Discussion lists	1	4	5	16	83	109	2.1	1.8
Video conferencing	0	0	0	1	108	109	1.3	0.5
Web conference with pictures (intranet as well as Internet)	0	0	0	1	108	109	1.2	0.5

N: Number of responses. SD: Standard deviation.

Facsimile, intranet, the Internet and mail are used daily or a few times per week by two thirds of the respondents. Document management systems are used many times a day by one third of the respondents. It is interesting to see that 108 of 109 respondents almost never use video conference tools or web conference tools. Nor are project management tools used very often, considering that most respondents stated that the frequency was a few times a week (22 respondents) or a month (34) or almost never (46).

Technological process support tools and perceived importance

When it comes to the perceived importance of technology support tools it is not surprising to see telephone (mean 8.9), e-mail (mean 8.8) and a standardized IT environment (mean 8.3) ranked as most important (see Table 7.16). However, software for technical estimates and calculations (mean 7.9) is ranked as more important than CAD software (mean 7.8), document management systems (mean 7.7), intranet (mean 7.5), the Internet (mean 7.3) and mail (mean 7.2) that all were said to be used many times a day or daily (see Table 7.15). Perceived importance of use of CAD software use shows a high standard deviation (2.9) which can be explained to some extent by the fact that consultants at two departments doing mostly investigations and feasibility studies almost never used CAD.

Table 7.16 Perceived importance of technological support tools.

Technological support tool	N	Mean	SD
Telephone	109	8.9	1.4
E-mail	109	8.8	1.6
Standardized IT environment (hardware/software)	106	8.3	2.1
Software for technical estimations	109	7.9	2.3
CAD software	109	7.8	2.9
Document management system	109	7.7	2.3
Intranet	109	7.5	2.2
Facsimile	109	7.5	2.2
Internet	109	7.3	2.4
Mail (traditional)	108	7.2	2.2
Knowledge maps - who knows what	109	6.9	2.1
Decision support	109	6.5	2.4
Project management software	108	6.2	2.5
Discussion lists	106	4.9	2.4
Groupware	107	4.6	2.5
Telephone conference	108	4.4	2.5
Web conference with pictures (intranet as well as Internet)	107	3.2	2.1
Video conferencing	107	3.1	2.0

N: Number of responses. SD: Standard deviation.

It is remarkable to see that all interactive communication tools for collaboration such as discussion lists (mean 4.9), groupware (mean 4.6), telephone conferences (mean 4.4), web conferences (mean 3.2) and finally video conferences (mean 3.1) are valued so low. The interview respondents emphasized cooperation and coordination as important issues in project organizations and for technical consultants, and it could therefore have been expected that cooperative tools allowing for many participants would be perceived as important and also be popular to use. Since the oldest

collaborative tools such as telephone conferences are also little used, it is not just to be explained by conservative behaviour patterns. When there is no old behaviour to transfer to new tools for collaboration, it will probably take even longer time before they will be used.

Experience of IT use

How do consultants experience IT? The questionnaire included ten assertions to which the respondents were asked to agree (giving 10 points on the scale) or disagree about technological tools, especially IT (see Table 7.17). The respondents most often agreed with the assertion "Our intranet is easily accessible to all staff who need it" (mean 7.6) and "Technology links all members of the company to one another" (mean 7.4). The respondents were more neutral to the assertions "Technology supports communities of knowledge sharers" (mean 4.9) and "Information systems are integrated and smart" (mean 5.0). Just above the middle of the scale and therefore slightly positive were assertions about access to tools, tools that support communication, external links, accessibility of corporate memory and real time information systems. Low participation in discussion groups may be attributed to the fact that there is no strong support for such arrangements. In the next section, additional obstacles to knowledge management initiations and knowledge transfer are presented.

Table 7.17 Experiences of technological support tools and especially IT.

Experience	N	Mean	SD
Our intranet is easily accessible to all staff who need it	107	7.6	1.9
Technology links all members of the company to one another	108	7.4	1.8
The tools (resources) work well and are appropriate	108	6.8	1.8
I have the process supporting tools (resources) I need	107	6.6	1.9
Technology that supports communication is rapidly placed in the hands of employees	105	6.3	2.0
Technology links all members of the company to all relevant external publications	107	6.3	2.0
Technology creates an institutional (corporate) memory that is accessible to the entire company	107	6.0	2.4
Information systems are real-time (updated information only)	104	5.7	2.1
Information systems are integrated and smart (talk to each other)	102	5.0	2.4
Technology supports communities of knowledge sharers	104	4.9	2.5

N: Number of responses. SD: Standard deviation.

7.4 Obstacles to knowledge transfer and to implementing knowledge management initiatives

From the literature review a list was made of common problems or obstacles to knowledge transfer and to implementing knowledge management initiatives (see Table 7.18). "People want to share knowledge but have no time" was perceived as the largest obstacle to knowledge transfer (mean 7.7), and 29 per cent of all respondents strongly agreed with this assertion and another 45 per cent just agreed to the assertion "no reward for knowledge sharing" (mean

6.6); 14 per cent of the respondents strongly agreed and 45 per cent just agreed. It is also interesting to find that 48 per cent of the respondents agreed that it is difficult to know where to store knowledge (mean 6.2) and that only 1 per cent strongly disagreed. There is also a problem in locating knowledge (mean 5.9) where 39 per cent agreed and 25 per cent disagreed with the assertion "knowledge is difficult to locate".

Table 7.18 Obstacles perceived to be the most frequent in transferring knowledge and implementing knowledge management initiatives.

Obstacle	N	Mean	SD
People want to share knowledge but have no time	109	7.7	1.5
No reward for knowledge sharing	107	6.6	1.8
Cost (lack of funding)	109	6.3	2.3
It is difficult to know where to store knowledge	109	6.2	1.6
Efforts wasted through re-inventing the wheel	108	6.1	1.9
Knowledge is difficult to locate	108	5.9	1.8
Knowledge from one project is difficult to generalize and use in other projects	109	5.8	1.8
Individuals do not share best practice	109	5.7	1.9
Training (lack of skills in knowledge management techniques)	108	5.6	2.0
Lack of understanding of knowledge management and its benefits	109	5.3	1.9
Current culture does not encourage knowledge sharing	108	5.2	2.2
Management acceptance (lack of management support and commitment)	109	5.1	1.9
The organization does not have offices that support knowledge sharing	109	4.7	2.4
The organization does not have the right information technology for sharing knowledge	108	4.5	2.0
Knowledge is more effectively shared with outside organizations	108	4.5	1.6
Individuals unwilling to share knowledge	109	4.4	1.9
Too little knowledge	108	3.8	1.8
Too much knowledge	108	3.5	1.7

N: Number of responses. SD: Standard deviation.

It is worth noting that most of the consultants (54 per cent) found that their offices support knowledge sharing, but a sizeable minority (25 per cent) found that offices did not. Only 17 per cent of the respondents thought that their organization did not have the right information technology for sharing knowledge while 57 per cent thought that they had the right information technology. Most respondents (58 per cent) believed that consultants are positive to sharing knowledge while only 15 per cent did not believe so.

Table 7.19 Nonparametric correlations for managerial obstacles (Kendall's t_b).

No.	Obstacle	14.8	14.9	14.10	14.11	14.12
14.8	Individuals do not share best practice	1	0.47	0.40	0.29	0.28
14.9	Individuals unwilling to share knowledge	0.47	1	0.37	0.35	0.23
14.10	Management acceptance (lack of management support and commitment)	0.40	0.37	1	0.49	0.40
14.11	Lack of understanding of knowledge management and its benefits	0.29	0.35	0.49	1	0.59
14.12	Current culture does not encourage knowledge sharing	0.28	0.23	0.40	0.59	1

All correlations are significant at the 0.01 level (2-tailed).

When analysing all obstacle variables and correlating these with background variables such as age, gender and education, the correlations were found to be low and in most cases not significant. Correlations were also generally low between the obstacle variables. Lack of time for sharing knowledge correlated, for example, only significantly with lack of funding. However, it was possible

to observe a cluster of managerial obstacles with much higher correlations, all significant at the 0.01 level (see Table 7.19).

One of the managerial obstacles was highly correlated to all the other four obstacles. This obstacle was lack of management support and commitment. This indicates that management acceptance is important for eliminating the other obstacles. The highest pairwise correlation was between lack of understanding of knowledge management and current culture not encouraging knowledge sharing (0.59).

7.5 Comparison with the 1997-98 study

Is it possible to find patterns that indicate change between 1997-98 and 2000 in the fundamental attitudes to learning and knowledge transfer? Of the questions asked in the initial survey, 45 recur in the second survey (see Table 7.20). Generally variables in the second study received higher values than the corresponding variables in the first study. Only five of the 45 variables got lower values in the second survey, and the differences were small. Slight reductions occurred for encouraging initiatives and experimenting in order to acquire knowledge (from a mean value of 6.3 to 6.2); tools work well and are appropriate (from a mean value of 7.0 to 6.8); and seeing quality audits as good opportunities for learning (from a mean value of 5.5 to 5.2).

Mean values of thirteen variables increased more than one grade on the scale in the second (2000) questionnaire. The largest observed differences were in the use of intranets and the Internet. Using the Internet more than doubled (from a mean value of 3.2 to 6.5) and use of intranets nearly doubled (from a mean value of 3.3 to 6.4)[36]. It should also be mentioned that the Internet as well as intranets have become more helpful over the two years between the studies. When the first study was made, intranets and the Internet had recently become available to all employees, and they should have been more comfortable with using web technology when the second study was made. The contents of both intranets and the Internet had also increased during these years and it would be possible to find more information there. It is therefore likely that the use of both the intranets and the Internet had increased greatly between the two surveys.

[36] In these two cases the respondents might have been influenced by the fact that the assertions were formulated differently in the two studies. In the first study the assertion was: "I use knowledge and information from the Internet at work" and the respondent had to consider a ten grade scale with verbal anchors. In the second study the assertion was rephrased to a question: "How often do you use the following technical support tools for managing knowledge?". Below the question there was a table of various technical support tools (intranets and the Internet among them) that the respondents had to consider according to the same ten grade scale with verbal anchors as for the first study (see Table 7.15). It is, however, difficult to see in what direction answers would be biased by the change. The variables are similar and scales are the same, but the Internet and intranet were presented along with other tools in the second study.

During the same period the use of information and knowledge from the department library had increased from a mean value of 4.7 to 6.9, and there is no explanation of why this should be the case. Much of the literature in the department libraries is product catalogues. As product companies and material suppliers have started to distribute compact discs as well as catalogues it could have been expected that the use of compact discs should have reduced the use of information from paper-based department libraries[37].

Table 7.20 Recurring questions in the 1997-98 and 2000 studies.

Assertions	1997-98		2000		Diff. in
	Mean	SD	Mean	SD	mean
We encourage initiatives and experimenting in order to acquire knowledge	6.3	1.5	6.1	2.1	-0.2
I use my experience from previous projects as a best practice when I participate in a new project	7.7	1.0	8.3	1.4	0.6
I use experience from previous projects that I have learned about from others as best practices when I participate in a new project	6.1	1.6	7.6	1.6	1.5
I learn by helping colleagues and others	6.4	1.5	6.8	1.6	0.4
I learn in my work by trying different tasks and by planned supervision	5.6	2.2	6.7	1.8	1.2
I believe quality audits are good opportunities for learning	5.5	2.1	5.2	2.0	-0.3
I learn by taking internal courses	4.6	1.9	5.4	2.0	0.8
I learn by taking external courses	5.6	2.0	5.7	2.1	0.0
I learn by attending internal conferences (*skråträffar, teknikområdesträffar*)	5.0	2.0	5.8	2.2	0.7
I learn by talking to colleagues at my office/department	6.6	1.4	7.7	1.6	1.2
I learn by talking to colleagues in my company but outside my office/department	4.4	1.9	5.7	2.3	1.3
I learn from interaction (credit and criticism) with clients	5.4	2.1	5.8	2.0	0.4
I learn from interaction (credit and criticism) with users	4.4	2.3	5.9	1.8	1.5
I learn from interaction with other technical consultants	4.6	2.0	5.2	2.1	0.6
I learn from interaction (credit and criticism) with suppliers	4.6	2.2	5.8	2.2	1.2
I learn from interaction (credit and criticism) with architects	3.8	2.2	4.9	2.4	1.2
I'm interested in trade associations related to my work	5.5	2.1	6.1	10.3	0.6
I learn by reading professional journals and magazines	5.5	1.4	6.4	2.0	0.9
I learn by reading books	5.0	2.0	6.1	2.1	1.1
I learn from using routines and checklists in my company's quality assurance system	4.6	2.1	4.9	2.3	0.3
I use information from the department library in my work	4.7	2.4	6.9	1.9	2.3
I want to learn more at work	7.6	1.4	9.0	1.1	1.4
I want to work with new systems and methods	6.9	1.4	7.8	1.5	1.0
I want more responsibility at work	6.6	1.4	7.3	1.7	0.7
I want to have a more qualified job content	6.6	1.5	7.6	1.6	0.9
Most changes are stimulating and provide new opportunities	6.3	1.7	7.8	1.5	1.5
I use much of my knowledge in my work	7.3	1.6	7.9	1.4	0.6
I plan my work	7.2	1.8	7.6	1.5	0.4
Much of my work is routine	5.0	1.7	5.0	1.5	0.0
My work contains elements of new demands and challenges	6.8	1.5	7.3	1.3	0.5
I contribute to solving most problems that occur in my job	7.7	1.4	7.6	1.3	-0.1
My work is meaningful and I feel motivated	7.2	1.4	7.8	1.4	0.5
There are good opportunities to make a career by doing a good job	5.5	1.9	6.1	2.2	0.7
I'm involved in my work and often do more than expected	7.1	1.6	7.1	1.5	0.0
I'm loyal to my company and sacrifice my private life for my work	7.2	1.9	7.4	1.9	0.2
I get a lot done at work	7.1	1.2	7.1	1.3	0.0
I often help others to solve problems that occur at work	6.3	1.8	7.0	1.8	0.7
I'm expected to share knowledge and experience with others at work	6.9	2.0	7.4	2.0	0.5
I often take new initiatives in my work	6.4	1.6	6.8	1.8	0.4
There are opportunities to learn things important to my work	5.0	1.6	5.2	2.0	0.2
We help and support each other at work	7.4	1.6	7.5	1.5	0.1
We are rewarded for learning at my job	5.3	1.8	5.2	2.2	-0.1
Internet	3.2	2.2	6.5	2.3	3.3
Intranet	3.3	2.2	6.4	2.4	3.1
The tools (resources) work well and are appropriate	7.0	1.3	6.8	1.8	-0.3

SD: Standard deviation.

[37] However, the correlation in the second survey between using information from the library and the two assertions about the use of compact discs (no. 2.29 respectively no. 2.30 in Appendix 2) were low (0.20 and -0.08) and not significant.

It seems that the consultants were more prone in 2000 to think that it is good to listen to users in order to produce what is wanted. “Learning from interaction with users” has increased by 1.5 from a mean value of 4.4 in the first study to 5.9 in the second. The variable shows significant correlation (0.01 level), primarily to learning from clients (0.77); learning from colleagues at other offices (0.45); and learning from other technical consultants (0.32). There are also significant correlations to the use of media such as the telephone (0.36) and telephone conferences (0.43). The increased mean value for learning from users might depend on an increased awareness of customers and users in society, in the construction industry today, and the ongoing debate in the press. However, the learning from client variable did not rise correspondingly (see Table 7.20).

Mean values of two variables measuring attitudes to the potential for learning had also increased since 1997-98. The variable stating that most changes are stimulating and provide new opportunities had changed from a mean value of 6.3 to 7.8, which is close to the answer: “yes, very much”. At the same time the variable “I want to learn more at work” increased from a mean value of 7.6 to 9.0, which definitely represents the interval “yes, very much”. The importance of learning and use of experience from other employees’ projects also increased greatly, the mean value rising from 6.1 to 7.6. This indicates that learning at department level or organizational level has improved its status and that it can be further improved if the companies succeed in employing younger people, as the variable related to learning from others’ projects had a significant (0.01 level) negative correlation (-0.26) with high age. Learning from projects carried out by others also showed a high correlation to learning by helping colleagues (0.45), learning by trying different tasks and planned supervision (0.39), talking to the colleagues at the department (0.41), and the use of information from the department library (0.35). Individual learning that comes from using one’s own projects again was ranked highest (mean 8.3) as a method for learning, having reached the top rank value (7.7) already in the 1997-98 survey.

7.6 Summary

Findings from the 2000 survey indicate that acquisition of knowledge and information by interactive communicative methods has an advantage over more passive introvert methods, which do not include talking to other people. There is also a distinction to be made between internal and external methods of acquisition, where proximity to the knowledge or information source is preferred by employees. Informal methods where people meet physically and talk face-to-face are the most frequently used methods of distributing and making meaning of knowledge. When it comes to organizational memory,

much knowledge was found to be stored in the heads of people. Knowledge about similar projects, about who knows what, about customers and competitors were categories of knowledge that were predominantly stored in the heads of people. Theories of action including shared assumptions about how tasks are performed were identified as the second most important means of storage for knowledge about processes, best practice and general know-how. Internal organizational and management information was the category of information that was found to be more dispersed than any other categories at different levels in the organization, whereas technical task knowledge such as similar projects, methods and processes and best practices were shared at department level.

When it comes to enabling conditions and facilitating activities, there are five types of these in addition to the sixth type, technological enablers. The first type, organizational structure, is perceived to be giving access to both internal and external knowledge holders. At the same time the respondents answered that there is insufficient time for learning things that are important for their work. The second type of enablers and facilitators, related to communication and monitoring of strategy, received generally low average values, implying that they are not perceived to provide much support for learning, nor offer strong rewards for knowledge transfer. When analysing the process type of enablers and facilitators, it was found that consultants mostly perceived that they were expected to share knowledge with their colleagues. However, geographically dispersed knowledge as well as lessons learned scored around average on the scale, indicating that these were less available at the organizational level but to a greater extent at the departmental level. The fourth type, culture, had higher mean values than the other types, and it seems to be a feature of the organizational culture in these companies to help each other in work. Values for perceived openness to knowledge and information as well as for encouraging experimenting just barely reached the upper half of the scale. When it comes to the fifth type, systems for training and learning, the learning process appears not to be driven by flexibility and desire to innovate. However, employees take responsibility for their own learning.

Three technological support tools were used many times a day by more than half of the respondents: telephone, e-mail and standardized IT platforms. These tools were followed by CAD, facsimile, the intranet, the Internet and document management systems that were used daily. From the intranet, internal services, such as administration, constituted the most frequently used function. Basic technological enablers such as telephone and e-mail were perceived as being the most prominent. Next came software for preparing technical estimates and CAD. More advanced tools for group communication were perceived as being of little importance. While intranets appeared to be easily accessible to most of those who needed it, but technology does not

provide strong support for communities of knowledge sharers, and on the whole, information systems currently in use were perceived as neither smart nor integrated.

The greatest reported obstacles to transferring knowledge and implementing knowledge management initiatives was that the respondents felt that they wanted to share knowledge but had insufficient time. This obstacle was followed by lack of rewards, too high costs and lack of funding. The perception of lack of time showed a significant correlation (0.01 level) only with a perception of lack of funds, not with other obstacles or background variables such as age, gender and function.

The comparative analysis of answers from 1997-98 and 2000 showed that the use of both intranets and the Internet was approximately doubled between the two studies. Learning from users and the use of experience from previous projects, learned from others, also increased heavily. The attitudes revealed in relation to seeing change as stimulating and wanting to learn more at work were also strengthened during the years. Only five of the 45 variables received lower values in the second study and in these cases the differences were small.

8 Knowledge management, obstacles and business strategies

In this chapter, the emphasis shifts towards a general discussion of results. While the results presented in the last two chapters were interpreted as descriptive statistics of single variables, related to the model in section 2.8 of knowledge transfer in technical consultancy organizations, the focus is now on identifying threads that lead to conclusions and managerial implications. Each section begins with an analysis of the results from both the 1997-98 study and the 2000 study, after which the combined results are reflected back to previous studies and general conclusions are drawn.

8.1 The knowledge transfer process

Construction technical consultants can be said to lack a separate process for knowledge transfer. Transfer can be claimed to be their core process, but for the consultants themselves, the transfer nature is hidden by the choice of concepts they use to describe their business process. However, it is possible to assign individual sub-processes of the knowledge transfer process, identified in Chapter 2, to the various activities in their business process, as was done in Chapter 5. For each of the transfer sub-processes, results presented in Chapter 6 from the 1997-98 questionnaire study, and results presented in Chapter 7 from the 2000 study, are compared to factor analyses performed only on data from the 2000 questionnaire study. Variables in the 2000 questionnaire have been allocated to transfer sub-processes in accordance with Chapter 7.

The purpose of using factor analyses is to identify concepts that link the earlier analysis in Chapter 7 to what will ultimately be spelled out as management implications. By reducing the complexity of the original questionnaire responses and using the knowledge transfer process model, it should be possible to throw light on earlier results in Chapters 5, 6 and 7, while also relying on observations reported by earlier investigators and principles they have formulated. The discussion should also make it easier to integrate and compare questionnaire data with the interview responses that were presented and analysed in Chapter 5.

For each factor analysis, all variables were tested and approved for fitness according to Barlett's test of sphericity and the Kaiser-Meyer-Olkin measure of sampling adequacy (see section 4.9). This means that no extra variables had to be eliminated from the factor analysis. The number of factors was chosen based on using a graphical scree test (Cattell, 1966). In two analyses, the

eigenvalue was less than one (<1) before the steep slope ended. For these analyses, Kaiser's criterion implying the inclusion of all factors with eigenvalues greater than one was used. For each sub-process factor, Cronbach's a (Ca) was calculated for the variables included (Cronbach, 1951). With a single exception, a exceeds 0.7, which would have been considered as good if the variables had constituted an index (Nunnally, 1978). The identification of factor labels is made more uncertain for a few factors because of the existence of intercorrelations in excess of 0.4. In two cases, variables with factor loadings lower than 0.4 were excluded before interpreting and labeling the corresponding factor.

8.1.1 Acquisition

The value of classifying methods for knowledge acquisition in two groups has been shown in Chapter 6 and 7. Both studies confirm that it is fruitful to use the distinction between internal and external methods for knowledge acquisition, as proposed by Dixon (1992). It has also been found in the first study (1997-98) that internal experience based methods, including oral communication, were perceived as being the most useful for acquiring knowledge and information. Internal experience based methods were followed by text based methods with proximity to the source, coming before methods based on oral communication with external actors, found further down the scale. Similarly the second study (2000) showed that acquisition by oral interactive communicative methods gains an advantage over the use of more passive introvert methods, which do not include talking to other people. For each group, informality was preferred before formality. The perceived usability of methods for acquiring knowledge seems to be highest for (1) internal methods, with proximity to the knowledge or information source, (2) informal methods, and (3) methods including oral communication.

When introducing factor analysis on the 25 reduced variables[38] representing the sub-process of knowledge acquisition, four factors explained 51 per cent of the variance. These factors were labeled (F1) Intradepartmental experience, (F2) Extradepartmental face-to-face communication, (F3) Textuality, and (F4) Authority sources (see Table 8.1).

The first factor in Table 8.1, interdepartmental experience, includes most of the internal methods including oral communication that were found in the descriptive analysis to be the most used for knowledge acquisition. Similarly the second factor, including variables with extradepartmental face-to-face communication, is related to external methods, among these being oral

[38] The original 27 variables in the second study (2000) were reduced (variable 1.12 and 2.5, see Appendix 2) to 25 in section 4.9.2 because the excluded variables were found not to belong to the normal distribution.

communication. The third factor, labeled textuality, is related to both introvert methods with physical proximity to the source, and with one exception, to external textual methods. So far, it has been possible to find similarities between the derived factors and results from the descriptive statistics. The division of knowledge according to acquisition from internal and external sources, outlined in section 2.6.2, seems to be a fruitful distinction within these technical consultancy companies. With factors F1 and F2 in mind, it might, however, be asked what can be considered the external boundary for acquiring knowledge. The results indicate that the distinction between intradepartmental and interdepartmental knowledge acquisition is more fruitful than that between intraorganizational and interorganizational knowledge acquisition. The choice of media for communication, in particular face-to-face oral communication, is an important aspect of knowledge acquisition. Using face-to-face communication can be seen as a consequence of high equivocality that can be reduced, as noted by Daft and Huber (1987), by the use of richer media (Daft and Lengel, 1984). The correlation analysis performed in Chapter 7 (Table 7.3) showed particularly high correlations between two intradepartmental oral communication methods and between four extradepartmental methods that included oral communication.

Table 8.1 Factor analysis of variables contributing to knowledge acquisition. Rotated component matrix with factor loadings.

Variables	F1	F2	F3	F4	Ca
I learn by helping colleagues and others	0.66				0.826
I learn in my work by trying different tasks and by planned supervision	0.63				
I use experience from previous projects that I have learned about from others as best practices when I participate in a new project	0.62			0.48	
I search our intranet for knowledge I need	0.59				
I learn by talking to colleagues at my office/department	0.59				
I have been involved in R&D projects where I have learned things useful in my work	0.55				
I search the Internet for knowledge I need	0.55				
I learn by informal talking to colleagues at my office/department, for example at coffee breaks, in the corridor and at lunch.	0.53	0.52			
I learn by talking to colleagues in my company but outside my office/department		0.79			0.830
I learn from interaction (credit and criticism) with users		0.77			
I learn from interaction (credit and criticism) with clients		0.74			
I learn by attending internal conferences (*skråträffar, teknikområdesträffar*)		0.62			
I learn by participating in discussion groups on the intranet (internal)			0.73		0.806
I learn by participating in discussion groups on the Internet (external)			0.70		
I learn by reading books			0.69		
I learn by reading professional journals and magazines			0.66		
I learn by reading internal publications and lessons learned			0.45		
I learn from interaction with other technical consultants			0.41		
I use knowledge from the department library in my work				0.62	0.733
I learn from interaction (credit and criticism) with architects				0.60	
I learn by taking internal courses				0.58	
I learn by participating in staff mentoring arrangements			0.41	0.55	
I learn from interaction (credit and criticism) with suppliers				0.46	

Extraction method: Principal component analysis. Rotation method: Varimax with Kaiser normalization. Missing values replaced with mean. Rotation converged in 9 iterations. Total variance explained 51%. Kaiser-Meyer-Olkin measure of sampling adequacy = 0.764. Barlett test of sphericity = 1321, significance p = 0.000. The number of factors extracted was decided with a scree-test. Two variables with factor loading <0.40 have been excluded when labeling the factors. (F1) Intradepartmental experience, (F2) Extradepartmental face-to-face communication, (F3) Textuality, (F4) Authority sources. Ca = Cronbach's a.

Compared to extradepartmental sources for knowledge acquisition, intradepartmental sources received higher mean values from respondents. Talking to colleagues at the department is still perceived as the most useful method followed by using experience from projects carried out by others. Acquiring knowledge from other projects can include both interdepartmental and interorganizational acquisition. However, results from interviews in the first study showed that it is very unusual to use knowledge from projects that have been carried out by consultants at other departments. Results from the second questionnaire study showed that knowledge from similar projects, best practice and know-how as well as methods and processes were stored at the individual level or at the department level, indicating why it is more difficult to acquire or retrieve experience based knowledge from other departments.

A high preference for using internal sources was expected. In her study of employees in the semiconductor industry in Japan and United States, Appleyard (1996) reached similar results. The respondents in Appleyard's study rated colleagues in their own company as their most important source of technical knowledge. However, her level of analysis was the organization and not the office or department. Similarly Davenport and Prusak (1998, p. 41) find that the preference for using knowledge from an individual that is well known might depend on trust, and that people usually get knowledge from their organizational neighbours.

Interdepartmental knowledge transfer such as learning from colleagues at other departments was perceived as less useful than learning from external human sources. The fact is that learning from colleagues at other departments was so unusual that the respondents in both studies found it easier to learn from clients, users, suppliers and other technical consultants (see Table 6.2 as well as Table 7.2). This raises the question of what can be considered as the organizational neighbourhood. The consultants perceive more distance to colleagues at other offices than to people from other companies, participating in the same temporary project organization, with whom they might be in daily or weekly contact.

An issue which has received less attention by most writers on knowledge management is the procedure for evaluating whether new knowledge and information is reliable. In section 5.1 it was found that at the output side, when knowledge crosses organizational boundaries, there are routines to certify information and knowledge transferred. It was also found that procedures for certifying input that crosses the boundary between two organizations are weaker. On the input side it is the responsibility of the individual engineer to decide what information and knowledge is reliable. Evaluation on the input side may be crucial when knowledge and information is acquired externally from outside the company. The construction industry is

well known for standardizing output through norms and practices, but little of the immaterial inputs to the technical consultancy companies is standardized, in contrast to the functions of project managers and authorized representatives to certify output.

8.1.2 Distributing and making meaning

Based on the second study (2000), it was found that informal methods where people meet physically and talk face-to-face are the preferred methods of distributing and making meaning of knowledge and information. Already in the first study (1997-98), it was observed that a group of intradepartmental methods were preferred before interdepartmental methods, an observation that was confirmed by the second study (2000). Not only that face-to-face meeting is a richer medium (Daft and Lengel, 1984), it also allows the consultants to discuss, interpret and analyse information, a set of activities through which meaning is made. Here it should be remembered that Dixon (1992) emphasized an overlap between the sub-processes contributing to the knowledge transfer process. This overlap is many times obvious for the sub-processes of distributing and making meaning, especially in situations that include face-to-face communication, where questions can be asked, discussed and clarified almost simultaneously. There are other methods for face-to-face communication based on virtual meetings such as videoconferencing and web-conferencing, but these four technical consultancy companies had only a few virtual meetings projects of a pilot nature at the time of the second study. The second most used methods also include face-to-face communication, but of a more formal character such as internal conferences, training and job rotation. In the third most used group of methods, culture has the function of a vehicle for distributing knowledge and information. Stories, myths and attributes such as corporate storybooks are examples of such vehicles.

Factor analysis of the 20 variables representing the theme of knowledge distribution and making meaning derived four factors explaining 52 per cent of total variance. Factors were labeled (F1) Interdepartmental learning, (F2) Culture of encouragement, (F3) Intradepartmental learning, and (F4) Future channels (see Table 8.2). The last factor had low internal consistency, judging by Cronbach’s a. However, the two variables included in the fourth factor were related to methods not yet implemented in the organizations.

Table 8.2 Factor analysis of variables contributing to knowledge distribution and making meaning. Rotated component matrix with factor loadings.

Variables	F/I	F1	F2	F3	F4	Ca
I learn by attending internal conferences (*skråträffar, teknikområdesträffar*)	F	0.81				0.701
I learn by talking to colleagues in my company but outside my office/department	I	0.75				
I learn by taking internal courses	F	0.64			0.41	
I learn by reading internal publications and lessons learned	F	0.46				
We try to encourage people to questioning assumptions in order to create knowledge	F		0.76			0.803
We are encouraged to participate in knowledge communities that we choose ourselves	F		0.72			
The company has a corporate story book	F		0.70			
We try to encourage open dialogues in order to acquire knowledge	F		0.64			
Our staff is encouraged to talk about their own work and the business in general in the future	F		0.60			
I learn in my work by trying different tasks and by planned supervision	I/F			0.67	0.43	0.767
I learn by helping colleagues and others	I			0.63		
We interview new employees in order to learn from their unique knowledge as they start to work at our company	F			0.60		
I learn by informal talking to colleagues at my office/department, for example at coffee breaks, in the corridor and at lunch	I	0.42		0.56		
I learn by talking to colleagues at my office/department	I			0.56		
We encourage job rotation and work with different tasks in different projects in order to acquire knowledge	F			0.50		
I learn by participating in staff mentoring arrangements	F				0.75	0.621
I learn by participating in discussion groups on the intranet (internal)	F/I				0.67	

Extraction method: Principal component analysis. Rotation method: Varimax with Kaiser normalization. Missing values replaced with mean. Rotation converged in 16 iterations. Total variance explained 52%. Kaiser-Meyer-Olkin measure of sampling adequacy = 0.782. Barlett test of sphericity = 760, significance $p = 0.000$. The number of factors extracted was decided with a scree-test. Three variables with factor loading <0.40 have been excluded when labeling the factors. F/I formal (F) and informal (I) methods for distribution and making meaning.
(F1) Interdepartmental learning, (F2) Culture of encouragement, (F3) Intradepartmental learning, (F4) Future channels. Ca = Cronbach's a.

Regarding the distinction between two main categories of knowledge and information distribution, intentional and unintentional distribution, proposed by Dixon (1992), it was found to be vague and of little use for understanding how knowledge is distributed in the four companies. Taking results from technical consultancy companies in the second study, it seems to be more fruitful to distinguish between formal and informal methods. For example, Dixon considers job rotation to be an unintentional method of distribution. It should rather be seen as a formal method where knowledge can be transferred intentionally as well as unintentionally. An example of what this method implies was found at one department where the manager rotated a recently hired expert across projects in order to let him contribute his expertise and transfer his particular knowledge to the other consultants. As a result he would also learn from expertise held by others, while creating his own knowledge map of his colleagues. Training, internal publication and briefings are formal methods that are considered as intentional distribution, but unintentional information and knowledge can be distributed as well. The receiver of information can make meaning of information that was not originally intended to be distributed. The factor analysis did not produce factors that could be readily identified with the intentionality categories of distribution proposed by Dixon (1992). On the other hand, there was no factor that clearly expressed the degree of formality, although F1 and F2

appear to be related to the use of formal methods and F3 to informal methods for knowledge distribution.

8.1.3 Organizational memory

Although knowledge can be embedded in procedures, processes, systems, machines, and documents, most knowledge was perceived as being stored in the heads of people. Results from the second study showed that knowledge about similar projects, who knows what, customers and competitors are particularly often perceived to be stored in the heads of people. Theories of action, including shared assumptions about how tasks are performed, was the second largest source of stored knowledge about processes and best practice and know-how. In practice, this implies that that knowledge also is stored in the heads of the employees. Records, electronic as well as paper-based, also store such knowledge but only half as many of the respondents thought so. Records, consisting of explicit knowledge, were instead found to store knowledge from similar projects and knowledge about the regulatory environment.

When respondents were asked about how the same categories of knowledge were distributed in the organization it was found that internal organizational and management information was most widely dispersed. Technical task knowledge such as similar projects, methods and processes and best practice were shared at department level. However, a more detailed analysis showed that the latter two categories of knowledge were dispersed at a divisional level in an organization organized according to technology and only at department level in an organization organized according to geography. A few practical matters such as access to file servers and databases, discussed in section 5.2, may also have influenced the perception of distribution. Knowledge about customers and competitors was preferably perceived to be shared at department level.

Factor analysis on the 11 variables representing various knowledge categories in the second study derived two distinct factors explaining 65 per cent of the variance. The factors were labeled (F1) Task knowledge, and (F2) Market knowledge (see Table 8.3).

Although all categories of market knowledge and four categories of task knowledge tend to be stored in the heads of people, there is a difference worth noting. Market knowledge (F2) relates, to a large extent, to managers such as line managers, account managers and project managers. Much of this knowledge is a result of the social relationship between the individual consultant and the customer and is updated at every meeting, every telephone call, every time the consultant or the customer reads something about the

other company in the press or even hears something from a third party. Such knowledge can also contain elements that would harm both parties if it was made public.

Table 8.3 Factor analysis of various knowledge categories and respondent perceptions of their cruciality. Rotated component matrix with factor loadings.

Knowledge category	F1	F2	Ca
Knowledge from similar projects	0.84		0.878
Methods and processes	0.80		
Internal organization and management information	0.72		
Regulatory environment	0.70		
Best practice and know-how	0.67		
Knowledge maps - who knows what	0.62		
Own services mix	0.60	0.49	
Competitors (what they know and do)		0.90	0.850
Own markets	0.45	0.75	
Emerging trends		0.70	
Customers (what they want, local standards, whom they work with)	0.55	0.64	

Extraction method: Principal component analysis. Rotation method: Varimax with Kaiser normalization. Missing values replaced with mean. Rotation converged in 3 iterations. Total variance explained 65%. Kaiser-Meyer-Olkin measure of sampling adequacy = 0.878. Barlett test of sphericity = 653, significance p = 0.000. The number of factors extracted was decided with Kaiser's criterion.
(F1) Task knowledge, (F2) Market knowledge. Ca = Cronbach's a.

Task knowledge (F1) is different from market knowledge (F2) in at least three ways. First it cannot harm someone if it is externalized and published, with the exception that it in some cases can be copied and the knowledge owner may lose a competitive advantage. Second, it can be divided into technical task knowledge and managerial task knowledge. Technical task knowledge includes technical methods and processes, best practice and know-how, knowledge from similar projects, and knowledge about the regulatory environment. Managerial task knowledge includes knowledge about the service mix of the company, internal organization and management information, knowledge maps and knowledge about the business processes such as described in section 5.1. Task knowledge is intended to be shared by and transferred to all employees in the company (with the exception of management information). Much more task knowledge than market knowledge is stored in records, transformations, structures and theories of action. Records, transformations and structures store explicit knowledge while theories of action largely store tacit knowledge, although theories of action are shared by the consultants. Market knowledge is said to be stored tacitly in the individual consultants' heads and in theories of action. Third, in construction technical consultancy, task knowledge (and especially technical task knowledge) does not have to be updated as often as market knowledge. As described in Chapter 1, product technology is stable and conservative, and the introduction of technological process support tools to some extent follows IT development. However, introduction of new IT does not necessarily imply that processes are changed very often, although it can make new knowledge available by embedding it in hardware and software.

It can be concluded that market knowledge and task knowledge have somewhat different behaviours in the knowledge transfer process, and that both categories need special attention and support to be transferred.

8.1.4 Retrieval

Both studies confirm the conclusions of Maister (1993) that one's own experience as well as the experience of colleagues is perceived as the most useful sources for retrieval of knowledge. According to Dixon (1992), individual and tacit knowledge is so well learned that it will be retrieved automatically when it is needed. It will therefore not come as a surprise that own experience is perceived as the most useful in both studies.

The most common methods for learning, creating and transferring knowledge are related to participation in the daily work at the office. The individual consultants acquire knowledge and experience through socialization. When analysing methods of controlled retrieval, the situation is similar to acquisition. First, intradepartmental methods based on communication with colleagues at the department were considered to be the most useful methods. Second, and perceived as less useful, interdepartmental communication with colleagues outside the department and third, as least useful, methods including systems where knowledge is embodied in textual documents. A similar pattern was also found in the factor analysis, where two underlying patterns of the eight retrieval methods were found. The factors were labeled (F1) Orality, and (F2) Textuality (see Table 8.4).

Table 8.4 Factor analysis of methods contributing to knowledge retrieval. Rotated component matrix with factor loadings.

Method	F1	F2	Ca
I learn by talking to colleagues at my office/department	0.79		0.771
I learn by informal talking to colleagues at my office/department, for example at coffee breaks, in the corridor and at lunch	0.77		
I use my experience from previous projects as best practice as I participate in a new project	0.74		
I use experience from previous projects that I have learned to know from others as best practice when I participate in a new project	0.70		
I learn by talking to colleagues in my company but outside my office/department	0.51		
I learn by participating in discussion groups on the intranet (internal)		0.82	0.848
I search our intranet for knowledge I need		0.75	
I learn from using routines and checklists in my company's quality assurance system		0.63	

Extraction method: Principal component analysis. Rotation method: Varimax with Kaiser normalization. Missing values replaced with mean. Rotation converged in 3 iterations. Total variance explained 55%. Kaiser-Meyer-Olkin measure of sampling adequacy = 0.719. Barlett test of sphericity = 214, significance p = 0.000. The number of factors extracted was decided with Kaiser's criterion.
(F1) Orality, (F2) Textuality. Ca = Cronbach's a.

The first factor consists of oral communication with colleagues and therefore includes both intradepartmental communication and interdepartmental communication. The second factor includes variables that represent textual communication. It can be argued that some of the experience based

knowledge retrieved from colleagues and their projects may be drawings and other documents, consequently textual. This might be true, but documents usually have to be analysed and interpreted together with the consultant who did the project, and knowledge is thereby retrieved in face-to-face communication. This also allows tacit knowledge to be transferred instead of only retrieving explicit knowledge from documents.

The categorization proposed by Dixon (1992) in controlled and automatic retrieval has also proved to be fruitful in the context of Swedish construction technical consultancy companies. When it comes to perceptions of how useful various methods of controlled retrieval of knowledge are, the distinction between individuals and groups of individuals proposed by Dixon is less fruitful. Instead, it was found useful to distinguish between retrieval by oral or textual communication, where the former was much more used.

8.1.5 Conclusions according to the knowledge transfer process

Drawing together the concepts identified in the four factor analyses in this section and results from the analyses in Chapters 6 and 7, a pattern is revealed (see Table 8.5). When transferring knowledge there are three criteria that determine whether a method for acquisition, distribution or retrieval is perceived as useful, first the physical proximity within the department, second the degree of informality and third the presence of oral communication preferably face-to-face. The importance of physical proximity verifies the results presented by Argote (1999, p.182) from her empirical studies of knowledge transfer in various US companies. The department boundaries seem to be much more important than theory indicates. Usually it is the organizational boundary that is discussed in literature, and most writers in knowledge management are interested in intraorganizational transfer of knowledge and information. Instead, the case of the four technical consultancy companies will in many situations remind of interorganizational knowledge transfer. Besides oral communication, there is textual communication that is especially prominent in the sub-processes for acquisition and retrieval of knowledge and information.

Thus far, the conclusions verify results found by Argote (1999, p. 182). She found that communication methods including rich media such as face-to-face interactions and personnel movement (through various project constellations, borrowing personnel, personnel rotation and trainee programs) are particularly powerful methods for knowledge transfer. They all permit transfer of both explicit and tacit knowledge and also allow for deep understanding and making meaning of the information being transferred. Thus, these methods are particularly well suited to identifying and acquiring knowledge to be transferred and used in local conditions. Once the information has been

applied to local conditions, Argote (1999) expects that more impersonal transfer mechanisms such as routines, procedures and databases will be used since they permit transfer of knowledge on a large scale. However, it seems that the large geographically dispersed technical consultancy organizations cannot easily use such methods. Since employees from different offices do not meet frequently and learn to know each other, this situation of transfer of knowledge between departments and offices can be compared to transfer between organizations.

Table 8.5 Factors identified by knowledge transfer sub-process.

Knowledge transfer sub-process	Factor label	
Acquisition	F1	Intradepartmental experience
	F2	Extradepartmental face-to-face communication
	F3	Textuality
	F4	Authority sources
Distribution and making meaning	F1	Interdepartmental learning
	F2	Culture of encouragement
	F3	Intradepartmental learning
	F4	Future channels
Organizational memory	F1	Task knowledge
	F2	Market knowledge
Retrieval	F1	Orality
	F2	Textuality

Regarding knowledge transfer between organizations within the same project organization, reality may be just the opposite. Instead of using methods that involve a great deal of personnel, it is possible that consultants from various organizations within the project are so familiar with one another that routines, procedures and databases are efficient methods to transfer knowledge.

8.2 Enabling and facilitating knowledge transfer

This section discusses organizational and technological conditions that enable and facilitate learning and knowledge transfer according to the theoretical review presented in section 2.7 and that are included in the model of knowledge transfer in a technical consultancy organization in section 2.8. These are: organizational structure, communication and the monitoring of strategy, process, culture, systems for training and learning, and technology. The discussion begins with organizational enablers and facilitators followed by technological enablers. A discussion of media choice and work attitude concludes the section.

8.2.1 Organizational enabling conditions and facilitating activities for learning and knowledge transfer in technical consultancy companies

Five types of enabling conditions and facilitating activities that concern aspects of organizing were identified in Chapter 2. The first type, organizational structure, was perceived in the second study (2000) to give

access to both internal and external knowledge holders. At the same time the respondents answered that there is not enough time for learning things important for work (see Chapter 7). In Chapter 6 it was found that younger consultants were much more mobile than older ones, when it comes to both changing work and changing company. This will have implications not only for the organizational structure and new recruitment, but also for finding employees in the age group of 30-40 years to assign to the function of department manager. Another issue related to organizational structure is the responsibility for knowledge management within the companies. In no case was there any identifiable employee who was particularly responsible for all knowledge management efforts in an entire company.

The second type, related to communication and monitoring of strategy, has generally low mean values in both studies. The consultants in the second study (2000) found low support for learning and neither was learning perceived to be rewarded. Most assertions about communication and monitoring of the strategy in the first questionnaire (1997-98) were related to organizational rewards, generally considered to be low. It was also found that rewards for learning had high correlation with encouraging new ideas, taking care of suggestions and proposals, and good opportunities to make a career by doing a good job.

When analysing the process type of enablers and facilitators in the second study (2000), it was found that consultants were expected to share knowledge with their colleagues. However, geographically dispersed knowledge as well as lessons learned scored around the average of the scale, indicating that these were not available at organizational level but possibly available at department level. Both the presence of a suggestions system and measures intended to minimize knowledge erosion were rare and well below the average of the scale. The freedom of planning and solving problems when working was perceived as relatively high. Among the job characteristics in the first study (1997-98), the tasks were perceived as challenging and varied, and the respondents used their competence in what they did. According to the first study, routines described in the quality assurance system were not perceived as easy to use, a result that has a positive significant correlation with low use and perceptions of low learning when using such routines.

The fourth type of enablers and facilitators, culture, was assigned higher mean values than the other types in the second study. However, both studies indicate that helping each other at work is a feature of the organizational culture. Openness to knowledge and information as well as encouraging experimenting are just scoring on the upper half of the scale. The second study (2000) indicated that although the respondents perceive that they were expected to share knowledge with their colleagues and felt strong loyalty to

the company, they perceived no strong cultural support for learning and knowledge transfer when it came to rewards and encouragement of new ideas and initiatives. When looking for obstacles in the second study, the respondents were neutral to the assertion that the present culture encourages knowledge sharing as well as to the assertion concerned with management support and commitment to knowledge transfer and implementation of knowledge transfer initiatives. Davenport et al. (1998) suggest that organizational culture should first support a positive orientation to knowledge (including that the employees are intellectually curious, willing and free to explore, and that executives encourage their employees to share); second to secure that people are not inhibited to share knowledge (not alienated or resentful of the company and do not fear that sharing knowledge will cost them their jobs); and third that new knowledge management projects fit with the existing culture. It seems from the discussion above that the responding consultants believe they are expected to share knowledge but lack of explicit incentives, strong cultural and strong management support, still prevents it from being a primary feature of their work.

Finally, it was concluded from both studies in Chapters 6 and 7 that for the fifth type of enablers and facilitators, systems for training and learning, the willingness to work with new systems and methods, the wish for more responsibility, and the wish to have more qualified work content were on the upper half of the scale; these three perceptions were correlated to (low) age of the responding consultant. Most consultants also wished to learn more at work but it was found that learning from training and courses was rather low. However, the second study indicates that employees feel that they take responsibility for their own learning. Responses in the second study showed that consultants graded all assertions related to systems for training and learning higher than in the first study.

When performing factor analysis on the 16 variables[39] from the second study that represent organizational enablers and facilitators, four factors were extracted that explained 62 per cent of the variance. In the fourth factor, there was one variable where the loading also on the third factor was in excess of 0.40, indicating the need for caution when labeling the fourth factor. The factors were subsequently labeled (F1) Process, (F2) Culture of encouragement, (F3) Incentives, and (F4) Acknowledgement and recognition (see Table 8.6). All factors were found to be internally consistent, based on Cronbach's a.

[39] The original 19 variables were reduced (variable 1.2, 1.13 and 9.21, see Appendix 2) to 16 in section 4.9.2 because the excluded variables were found not to be normally distributed.

Table 8.6 Factor analysis of variables representing five types of organizational enablers and facilitators. Rotated component matrix with factor loadings.

Variables	E/F	F1	F2	F3	F4	Ca
Lessons learned from different projects are made easily accessible to all in the company	P	0.78				0.760
The company has a way of minimizing knowledge erosion	P	0.69				
The company has a well implemented suggestion system	P	0.68				
We send people to conferences in order to acquire knowledge	T	0.54				
A climate of openness and trust permeates the organization	C		0.74			0.777
The organization encourages and facilitates knowledge sharing	S		0.65			
Flexibility and desire to innovate drive the learning process.	T		0.64			
We encourage initiatives and experimenting in order to acquire knowledge	C		0.47			
We are rewarded for learning at my job	S			0.81		0.701
There are good opportunities to make a career by doing a good job	S			0.54		
There are opportunities to learn things important to my work	O			0.43		
Employees take responsibility for their own learning	T				0.70	0.714
I have access to knowledge holders both inside and outside the company	O				0.69	
Geographically dispersed knowledge is integrated in the corporate memory and made available within the company	P	0.47			0.63	
I'm expected to share knowledge and experience with others at work	P				0.57	
We help and support each other at work	C			0.42	0.49	

(E/F) Type of enabler/facilitator: (O) Organizational structure, (S) Communication and the monitoring of strategy, (P) Process, (C) Culture, (T) Systems for training and learning.
Extraction method: Principal component analysis. Rotation method: Varimax with Kaiser normalization. Missing values replaced with mean. Rotation converged in 12 iterations. Total variance explained 62%. Kaiser-Meyer-Olkin measure of sampling adequacy = 0.823. Barlett test of sphericity = 679, significance $p = 0.000$. The number of factors extracted was decided with Kaiser's criterion.
(F1) Process, (F2) Culture of encouragement, (F3) Incentives, (F4) Acknowledgement and recognition. Ca = Cronbach's a.

The first three factors coincide to a large extent with three types of enablers and facilitators. The first factor, process, contains variables mostly related to process enablers and facilitators. The exception, sending people to conferences, represents systems for training and learning and also contributes to placing learning in a process perspective. Culture of encouragement, the second factor, comprises most assertions related to cultural enablers and facilitators. Here, both the exceptions, "the organization encourages and facilitates knowledge sharing" and "flexibility and desire to innovate drive the learning process" are close to what major writers emphasize as features of a knowledge friendly culture. The third factor, incentives, includes almost only assertions related to the "communication and the monitoring of strategy" type of enablers and facilitators. All three assertions in Table 8.6 related to this type of enablers and facilitators concern incentives and rewards. The fourth factor, acknowledgement and recognition, is difficult to refer to a single type of enablers and facilitators.

8.2.2 Technological enabling conditions for learning and knowledge transfer in technical consultancy companies

There are a few knowledge management initiatives described in Chapter 5 that can be claimed to be technology centred initiatives. Most of these initiatives do not follow a codification strategy but rather a strategy of personalization, as discussed already in Chapter 1. Tacit knowledge is important in technical

consultancy companies, and the importance of finding a consultant who knows and talks, rather than searches for information in documents, where it might or might not exist, is often emphasized. Many of the knowledge management initiatives mentioned by the interview respondents in the second study (2000) are in their earliest stages or have not even reached their starting point yet. A great deal of time and effort seems to have been spent on creating standardized IT platforms and the base and structure for intranets. It can therefore be expected that companies are now going to start several knowledge management initiatives with IT tools as a base and support.

In Chapter 5 and Table 5.4 it was found that three of the four technological enablers proposed in Chapter 2 were represented in the technical consultancy companies. Moreover, when analysing knowledge transfer tools and knowledge transfer sub-processes in Chapter 5, it was found that knowledge transfer tools supported acquisition, distribution, making meaning and retrieval of knowledge and information. Knowledge mapping tools were found to support acquisition and retrieval, and memory tools were found to support the knowledge transfer sub-process of organizational memory. No tool was found that could be assigned to the fourth category of technological enabling tools, that of knowledge combination tools.

In the quantitative analysis of the second study in Chapter 7, it was found that three technological support tools were used many times a day by more than half of the respondents. These tools were the telephone, e-mail and standardized IT platforms. These were followed in order by CAD, facsimile, intranet, the Internet and document management systems that were used daily. Basic technological tools such as telephone and e-mail were also perceived as being the most important. Next as important were software for preparing technical estimates and CAD. More advanced tools for group communication were perceived as being of little importance[40]. While intranets appeared to be easily accessible to most of those who needed it, current technology appears not to provide strong support for communities of knowledge sharers, and on the whole, information systems currently in use were perceived as being neither smart nor integrated.

Among the services present on intranets during the spring of 2000, administrative services are the most frequently used, followed by document

[40] The analysis of the knowledge transfer process show that most knowledge is acquired, distributed, stored and retrieved within the department. More advanced tools for group communication were not in use during the second study (2000) and these tools might not be needed within a department. However, if the pattern of interaction changes so that knowledge from other departments and offices would be shared and used to a greater extent, it would be more efficient to meet virtually and thereby reduce time and costs. There are similarities with the introduction of the Internet. When interviewed in the first study, many consultants said that the Internet was not useful for them in their work. The low frequency of usage was confirmed by questionnaire responses. Two years later in the second questionnaire, Internet usage was much higher. The consultants had found how they could use the Net and what information they could find there.

management and knowledge from projects in progress. That administrative services would figure prominently among intranet use was to be expected from the analysis of organizational memory, where it was found that internal organization as well as management information and knowledge were mainly stored in electronic records. In a survey conducted by Chabrow (1998), 988 responding managers listed what applications were included in their intranets. Most frequently included were one's own product catalogues and purchase orders, but these are largely irrelevant to professional services. More to the point is that catalogues and orders were followed by document storage (38 per cent of the respondents), customer records (38 per cent) and policies and procedures (36 per cent). However, with the survey of Chabrow in mind, it was surprising that knowledge about customers and competitors on intranets was little used or not at all. The trivial reason for this was revealed in the interviews with managers and IT experts in the second study, where it was found that there were no systems for customer and competitor knowledge on the intranets of the four companies. In agreement with this absence of systems, it was found in the analysis of organizational memory that such knowledge was mainly stored in peoples' heads, and that it was shared basically on department level and no further.

Factor analysis of the 18 variables representing various IT tools and how much they were used at the time for the second study, found four factors explaining 65 per cent of the variance (Table 8.7). Factors were labeled (F1) Conference and groupware, (F2) Basic new media, (F3) Traditional media, and (F4) Software tools. The first three factors had internal consistency well above the 0.7 value recommended for Cronbach's a. The last factor was below 0.7, but as long as the factor is not used as an index, this low value for internal consistency can serve merely as a warning when drawing conclusions based on F4. The importance of measuring internal consistency with Cronbach's a will decrease if the factors derived are clear, easy to interpret and fit the theories or studied phenomena that generated the variables (Gorsuch, 1983).

The first factor, Conference and groupware, includes collaborative knowledge transfer tools (see section 2.7.2) with the exception of decision support tools. These collaborative knowledge tools all had in common that they were not yet in common use and available to consultants in the four companies. Many of the tools are based on new developments in information technology. The second factor, Basic new media, includes further tools that imply the use of new media as well. The difference is that these tools are in use, and most of them on a daily basis, as the analysis in Chapter 7 showed. The third factor, Traditional media, collects more traditional media of which the telephone and traditional mail were important already in the late nineteenth century when the first Swedish technical consultancy companies were founded. The telephone is still the most frequently used technology based medium at the surveyed

departments and it is also considered as the most important technological support tool. The last factor, Software tools, includes three kinds of software: CAD tools and software for technical estimations, in use for performing the professional technical tasks, and project management software primarily used by project managers and department managers.

Table 8.7 Factor analysis of various how much various technical tools are used. Rotated component matrix with factor loadings.

Variables	F1	F2	F3	F4	Ca
Web conference with pictures (intranet as well as Internet)	0.83				0.794
Groupware	0.75				
Video conferencing	0.68				
Knowledge maps - who knows what	0.64				
Decision support	0.60			0.42	
Discussion lists	0.58				
Telephone conference	0.49		0.46		
Intranet		0.81			0.786
Internet		0.77			
E-mail		0.74	0.40		
Standardized IT solution		0.64			
Document management system		0.58			
Facsimile			0.83		0.786
Telephone			0.81		
Mail (traditional)			0.75		
CAD software			-0.28	0.78	0.492
Project management software			0.36	0.54	
Software for technical estimations			-0.17	0.49	

Extraction method: Principal component analysis. Rotation method: Varimax with Kaiser normalization. Missing values replaced with mean. Rotation converged in 8 iterations. Total variance explained 58%. Kaiser-Meyer-Olkin measure of sampling adequacy = 0.692. Barlett test of sphericity = 687, significance p = 0.000. The number of factors extracted was decided with a scree-test.
(F1) Conference and groupware, (F2) Basic new media, (F3) Traditional media, (F4) Software tools. Ca = Cronbach's a.

Looking at factor loadings for F3 and F4, there surfaces a negative link between use of CAD software as well as software for technical estimations and on the other hand use of traditional media. At the same time, the use of project management software receives positive loadings on both F3 and F4. When studying Kendall t_b correlations it was found that variables belonging to Traditional media (F3) have positive and significant correlations at the 0.01 level with both high age and high functional level of responding consultants. CAD software and software for technical estimations in F4 are both used for performing the professional technical tasks. Both variables correlate significantly and negatively to high age and higher functional level in the organization. A coherent explanation of these findings will be attempted in the next section.

It can be concluded that the presence of IT tools at the four companies primarily supports transfer of explicit knowledge. The Internet and the intranets have provided opportunities to transfer tacit knowledge as well, obviously because web-based media are richer than other IT media. However, most applications on these intranets are not collaborative, cannot be seen as information mapping, nor do they work as information agents or data mining tools that could capture tacit knowledge. Instead administration, management

systems, document management and databases seem to have been the most frequently used intranet services in the 2000 study.

8.2.3 Media choice and work attitude

Can we say that there is a stability in fundamental attitudes to learning and knowledge and that these attitudes have been unaffected by the introduction of intranet support? Of the questions asked in the initial survey, 45 recur in the second survey. By comparing separate two-factor analyses of responses to 44 of the recurring questions[41] in the first and the second surveys, it should be possible to identify underlying shifts in attitudes, more so than by only comparing response means. Four background variables were also added to the analysis: age, gender, function and education.

The first impression when trying to identify the two factors (see Table 8.8) is that the introvert/extrovert personality dimension familiar from the work of Eysenck (1970) appears to emerge[42]. However, this dimension does not take the form of a single factor. Instead, the first factor (F1) is coloured by problem solving, by communication and by motivated learning. The second factor (F2) is characterized by potential for competence development and an emphasis on questions that contain the verb "want". The negative loading of the age variable is worth noting. The general picture that emerges is one of a cluster of predominantly younger employees who value learning and knowledge as opposed to clients and problem solving. However, there is one exception, insofar as there is a strong outward element in their preference for using the Internet as a source of information and knowledge.

[41] The original 45 variables were reduced to 44 in section 4.9.2 because the excluded variable (variable 2.5 in the second study, see Appendix 2, corresponding to variable 66 in the first study, see Appendix 1) was found not to be normally distributed in the second study.

[42] Eysenck's second dimension or factor is the stability/emotional dimension.

Table 8.8 The rotated component matrix for a two-factor solution of the 1997-98 study.

Variables	F1	F2	Ca
I'm loyal to my company and sacrifice my private life for my work	0.75		0.905
I'm involved in my work and often do more than expected	0.74		
My work is meaningful and I feel motivated	0.69		
I contribute to solving most problems that occur in my job	0.67		
I'm expected to share knowledge and experience with others at work	0.66		
I learn from interaction (credit and criticism) with clients	0.64		
I often help others to solve problems that occur at work	0.64		
My work contains elements of new demands and challenges	0.63		
I learn from interaction (credit and criticism) with users	0.59		
I plan my work	0.58		
Function	0.58		
I use much of my knowledge in my work	0.56		
I often take new initiatives in my work	0.53		
We help and support each other at work	0.51		
I use experience from previous projects that I have learned about from others as best practices when I participate in a new project	0.49		
I learn from interaction (credit and criticism) with suppliers	0.49		
I'm interested in trade associations related to my work	0.48		
I learn by talking to colleagues in my company but outside my office/department	0.45		
There are opportunities to learn things important to my work	0.44		
I learn from interaction with other technical consultants	0.42		
I want to have a more qualified job content		0.79	0.778
I want more responsibility at work		0.78	
I want to learn more at work		0.70	
I want to work with new systems and methods		0.62	
I learn by helping colleagues and others		0.58	
Age		-0.58	
I learn in my work by trying different tasks and by planned supervision		0.56	
Most changes are stimulating and provide new opportunities	0.45	0.51	
I learn by talking to colleagues at my office/department		0.51	
Internet		0.47	
I learn by reading books		0.44	
Intranet		0.42	

Extraction method: Principal component analysis. Rotation method: Varimax with Kaiser normalization. Missing values replaced with mean. Rotation converged in 3 iterations. Total variance explained 31%. Kaiser-Meyer-Olkin measure of sampling adequacy = 0.719. Barlett test of sphericity = 1695, significance p = 0.000.
(F1) Communication and motivated learning, (F2) Learning and knowledge. Ca = Cronbach's a.

Again using the same variables but relying on data from the 2000 study, a new two-factor solution was produced. Again, the first factor was found to reflect motivated and communicative attitudes (see Table 8.9). Here, the clue to finding a more appropriate label for the first factor is the outgoing, customer oriented character of several variables that are highly correlated with the first factor. Also, there is a strong element of problem solving. The second factor has lost its emphasis on "want" variables but still keeps its internal focus as well as its negative correlation to high age. The outward element with Internet is removed and replaced by learning from other consultants and the architect, probably within the project organizations. It is also worth noting that the function variable correlates with the first factor in both studies. As observed in the previous analysis of technological enablers, the function variable correlates significantly according to Kendall's t_b at the 0.01 level with old media such as traditional mail (0.40), telephone (0.27), and facsimile (0.26), but also with telephone conferencing (0.45). This means that project managers are more likely than assistant consultants to be identified with the first factor. From both studies, it is thus clear that one communicative problem solving and one learning and knowledge focused factor can be identified.

Table 8.9 Factor loadings in rotated component matrix for a two factor-solution of the 2000 study.

Variables	F1	F2	Ca
I often take new initiatives in my work	0.74		0.888
I often help others to solve problems that occur at work	0.72		
I'm involved in my work and often do more than expected	0.70		
My work is meaningful and I feel motivated	0.63		
I'm expected to share knowledge and experience with others at work	0.61		
I contribute to solving most problems that occur in my job	0.61		
I'm loyal to my company and sacrifice my private life for my work	0.56		
I get a lot done at work	0.55		
Intranet	0.54		
I plan my work	0.53		
My work contains elements of new demands and challenges	0.52		
I learn from interaction (credit and criticism) with users	0.51		
There are good opportunities to make a career by doing a good job	0.50		
Function	0.49		
I learn from interaction (credit and criticism) with clients	0.47		
I use much of my knowledge in my work	0.46		
I learn by talking to colleagues in my company but outside my office/department	0.46	0.45	
I learn by attending internal conferences (*skråträffar, teknikområdesträffar*)	0.42		
I use experience from previous projects that I have learned about from others as best practices when I participate in a new project		0.72	0.790
I learn by helping colleagues and others		0.59	
I learn by taking external courses		0.56	
I learn in my work by trying different tasks and by planned supervision		0.55	
I learn by taking internal courses		0.55	
I use my experience from previous projects as best practice as I participate in a new project		0.53	
We encourage initiatives and experimenting in order to acquire knowledge		0.52	
I use information from the department library in my work		0.52	
I learn by talking to colleagues at my office/department		0.51	
Gender	0.42	-0.49	
I learn from interaction with other technical consultants		0.49	
I learn from interaction (credit and criticism) with architects		0.43	
I learn from using routines and checklists in my company's quality assurance system		0.43	
Most changes are stimulating and provide new opportunities		0.41	
We help and support each other at work		0.41	
Age		-0.41	

Extraction method: Principal component analysis. Rotation method: Varimax with Kaiser normalization. Missing values replaced with mean. Rotation converged in 3 iterations. Total variance explained 28%. Kaiser-Meyer-Olkin measure of sampling adequacy = 0.697. Barlett test of sphericity = 2775, significance $p = 0.000$.
(F1) Communicative problem solving, (F2) Learning and knowledge. Ca = Cronbach's a.

The advantage of relying on a two-factor solution is the ability to map the outcome unambiguously in two dimensions. If we label the first second-survey factor (still containing only the variables recurring from the 1997-98 survey) "Communicative problem solving" and the second factor "Learning and knowledge", positions in a diagram can be assigned to various media. However, as the second questionnaire included several more questions on media choice and media use, there is an opportunity to expand the range of variables included in the analysis. This time, there are the same four background variables as in the previous two analyses, the 44 recurring variables but also 13 variables representing use of various media from theme 10 (see Appendix 2), all in all 61 variables. Next, the fundamental stability of the first two-factor solution with data from the 2000 study is confirmed by the similar second two-factor solution based on 61 variables. Factor labels show the same pattern and can be retained; the small difference between the two two-factor solutions is mostly attributable to the fact that media variables have

been added. Media choice can now be plotted according to the new two-factor analysis (see Figure 8.1). It is immediately obvious that old media score much higher on the first factor. Correlations with Kendall's t_b are significant at the 0.01 level and range from 0.40 to 0.50 within the group of old media and from 0.23 to 0.27 with increased age. The connection between the first factor and old media could simply be attributed to the higher average age of these respondents, but another explanation is that the apparent conservatism in media choice is due to restrictions in interfirm communication. The communicative problem solving factor goes along with the conservative media choice that minimizes the difficulties in communicating with external organizations.

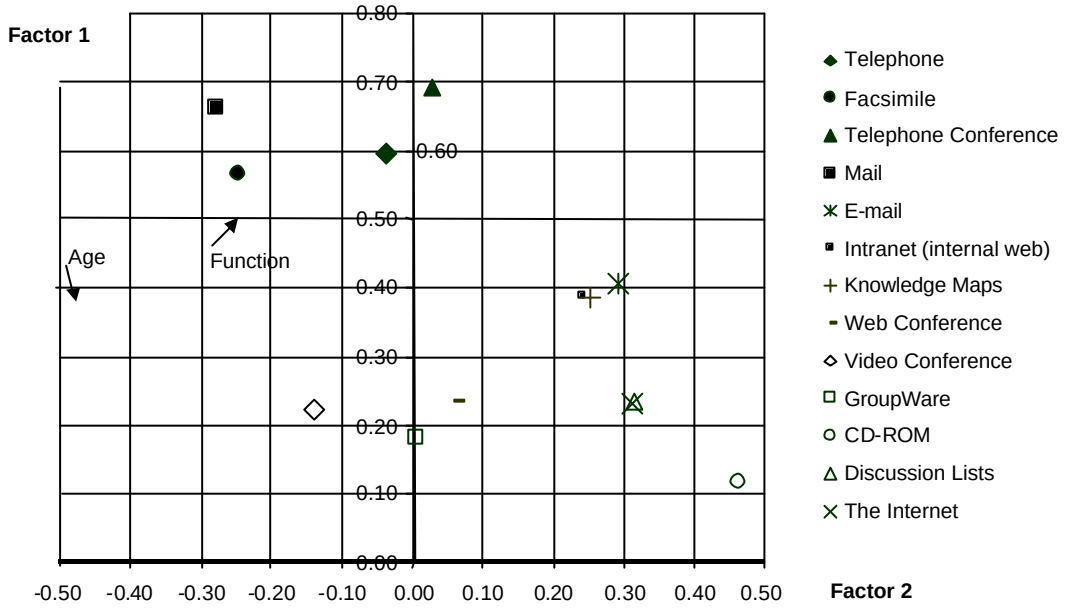

Figure 8.1 Plot of various media in the two-factor solution for the 2000 survey. Factor 1 was labeled "Communicative problem solving" and factor 2 "Learning and knowledge".

8.3 The knowledge conversion process

In this section the results are discussed according to Nonaka and Takeuchi's (1995) four-mode process of knowledge conversion described in Chapter 2 and included in the model of knowledge transfer in a technical consultancy organization in section 2.8. As has been seen, much knowledge is tacitly stored in the consultants' heads. Tacit knowledge can be transferred through socialization, a slow process that reaches only a few consultants in the organizational neighbourhood. The alternative is to make the tacit knowledge explicit and transfer it to a much wider group of consultants. In explicit form, this knowledge is also easier to combine with other explicit knowledge, and this combination may create new knowledge that later can be internalized and used.

8.3.1 Socialization: tacit to tacit

The mode of socialization is the most influential mode of transferring knowledge in technical consultancy companies, and not much seems to have changed between the two surveys in 1997-98 and 2000. The most common method for a consultant to acquire knowledge is to ask a colleague who knows, or who knows someone who knows. Oral face-to-face communication is favourable when learning about new technology, methods or problem solving. In spite of new information technology, engineers prefer to exchange knowledge orally with their colleagues at the department. To date, personnel turnover has been low at technical consultancy firms, and slow transfer processes such as socialization have become acceptable because time has not been limited in a learning perspective. The number of consultants at the department and other consultants in each consultant's personal network have kept low the number of personal sources for acquiring and retrieving knowledge for the individual consultant. Furthermore, technology change in the construction industry has been sluggish, which also implies that it takes a long time for construction knowledge to become obsolete. Consequently, there are or have been extensive opportunities to transfer by socialization what has become practice, and this has reduced the need for standardized processes, at least before the opportunities provided by new IT tools emerged and in a way shortened the time perspective. IT tools such as video conferencing, web conferencing, telephone conferencing and, to some extent, discussion groups in communities of practice are often said to enable socialization at distance (Junnarkar and Brown, 1997). However, in the analysis in Chapter 5 of IT tools available in the four companies, and in the analysis of the use of these tools (Chapter 7), it was found that such enablers for interactive communication - and thereby socialization - were far from

being in common use, and that most of them were not even available to employees.

Socialization both outside and within the organizations appears to develop primarily through meetings during the service process and the assignments performed. It is concluded that the technical consultants are quite familiar with the socialization process but not with how to take advantage of IT tools for enabling socialization at distance. Unfortunately, relying mostly on the device of socialization, it takes a long time to transfer knowledge to large groups of consultants, and to achieve organizational learning. Socialization tends to focus learning too much at the individual level, as claimed by Matzdorf and Price (2000) in their investigation of barriers to organizational learning in the UK chartered surveying profession, and not enough at the team learning level, which should have been better from a knowledge transfer perspective.

8.3.2 Externalization: tacit to explicit

Externalization is what occurs when the consultants translate the needs of clients and users into design. Relying on their tacit understanding and knowledge of design methods and of constructed facilities, they are able to produce documents and drawings. Office infrastructure including telephones, facsimiles, networks, and IT tools such as CAD, word processors, and e-mail is well developed in the four technical consultancy companies studied. The numerous reviews identified in the business processes mapped in Chapter 5 are examples of where externalization occurs. The knowledge transfer sub-process of making meaning, including interpretation where participants at meetings describe their views, externalizes tacit knowledge into explicit knowledge. Furthermore, creation of explicit knowledge takes place when consultants write e-mail and take notes. So far it can be said that technical consultants in general are good at externalizing knowledge.

In another sense, technical consultants are less successful in externalizing knowledge. Process descriptions and method descriptions of professional technical tasks are still in their early development stages, and best practice reports and white papers are also uncommon. The number of formal interdepartmental interactions and cooperative events is low and these do not appear to provide adequate support for knowledge creation and transfer. Internal conferences for the various specializations within the four companies are held thus only once a year, and individual consultants usually attend these conferences only every second year. Internal and external discussion groups are little used, and internal discussion groups had been tried but failed to be successful. Still in early 2000, there was little or no use of more recent and

more advanced IT tools to help the consultants to externalize knowledge, such as visual thinking tools, digital whiteboards, and groupware.

The interviews with department managers also show that there are a few groups of consultants that emerge as pockets of resistance to making their knowledge explicit. Consultants in these groups appear, in the views of their managers, to feel personal ownership of their expert knowledge and it is easy to attribute to them the feeling that it makes them indispensable to the company. Another interpretation of why these consultants appear to be unwilling to share their specialized knowledge is that they fear the possibility of losing social interaction with the clients if they share their knowledge freely with other consultants.

8.3.3 Combination: explicit to explicit

If knowledge is combined new knowledge can be created. Informal face-to-face discussions at the department were found to be the most usual method of distributing and making meaning of knowledge, and they are also a good opportunity for transferring and combining explicit knowledge. Opportunities to combine explicit knowledge in technical consultancy companies are also found when consultants meet in projects as mentioned earlier. Moreover, knowledge can be presented and combined during training events and courses. A broad spectrum of courses was presented in Chapter 6 but the annual reports show that the average time spent in training and courses is just a few days a year per employee. The need for more training was emphasized at the departments studied, particularly in use of IT tools, as was concluded in the analysis of questionnaire responses from the first study in 1997-98. In general, the opportunities to learn things needed at work were perceived as small.

Knowledge in e-mail form was available to the sender and the receiver, but no full-scale services in the consultancy companies used intelligent agents, data warehouse solutions, or even search engines that have access to all databases, mail servers, and file servers at the companies. Much knowledge that had been externalized in projects and stored in e-mail, letters, project reports and other documents was not made available and would soon be forgotten. Although the use of knowledge and best practice from other projects was ranked high both as a method for acquiring knowledge and information and for retrieving knowledge and information, the results indicate that such knowledge was primarily stored in the heads of people, and that it was shared mainly at department level. Technologically organized companies were slightly better at sharing such knowledge than geographically organized companies, and it would also be shared at division level or within the specialization. However, between the two surveys, there were considerable improvements in the

intranets, increasing the opportunities to combine knowledge. Much more information and knowledge had become available, and the comparative study presented in Chapter 7 confirmed the expected increase in use of both the intranets and the Internet between 1997-98 and 2000.

During the surveys, it was also observed that few serious attempts had been made to create a shared language that would have enabled more efficient storage of knowledge. Although technical consultancy has a long tradition, enshrined in a professional language, this was said to be not very useful for communication and codification of knowledge by the department managers who had tried to codify knowledge when experimenting with design databases and, more recently, with knowledge maps.

8.3.4 Internalization: explicit to tacit

In the internalization mode of knowledge conversion, explicit knowledge is transformed back to tacit knowledge in other individuals. This means that the consultant has to move from theoretical knowledge of something, from what can be seen in manuals, work descriptions or other documents and put this knowledge into practice. A typical example of this was found at the companies when the consultants tried to learn a new release of the CAD software. There was usually "no time" for courses so they used their experience from previous versions and the manuals with new information, and they proceeded through learning by doing. Two of the companies used web-based training, which can be considered as enabling internalization, especially if it is interactive and based on learning by doing. However, according to the interviews, the obstacle of insufficient bandwidth remained for at least some offices.

As internalization depends strongly on individual abilities to make meaning out of explicit knowledge, organizational and technological enablers that support interpretation and analysis would also be useful for internalization. Information technology in the shape of data mining tools, simulation tools, and applications based on visualization technologies can enable this process of transformation. Not many of these tools were in use in the technical consultancy companies, but there were exceptions. At the departments specialized in roads and railways, one CAD program was used for road design, where it was possible to make a simulated tour of the road in the CAD model. This gave the consultant a better understanding of how the road would appear in the future and it was possible to make adjustments to fit the road better to the landscape.

Another issue related to internalization is the apparent lack of practical knowledge and experience from construction sites and the management of

constructed facilities. In section 5.1.3 it was pointed out that projects are monitored throughout construction and afterwards until the guarantee inspection is made. It was found in the interviews in the first study (1997-98) that monitoring was carried out by the authorized representative and the project manager. All other consultants who participated in projects stated that they got received too little feedback from site and from their project managers as well. One or two site visits at larger projects were usual, but not more. Smaller sites were never visited. Usually the site visits took place after construction activities had been completed, when it was no longer possible to talk to site supervisors and craftsmen that had used the design documents.

8.4 Obstacles to knowledge transfer and to implementing knowledge management initiatives

The questionnaire in the second survey showed that the largest obstacle related to implementing knowledge management initiatives was that the respondents felt that they wanted to share knowledge but had no time. This is not surprising; Chase (1997) found lack of time to be the third greatest barrier to knowledge transfer after cultural issues and lack of ownership to the problem.

Lack of time was followed as a perceived obstacle by lack of rewards and high costs. Moreover, it was found in the second survey that the respondents answered neutrally to the question of whether their organizational culture supported learning and knowledge transfer. The difficulty of changing that attitude can, according to Ruggles (1998, referred to in section 1.5.2) be one of the greatest obstacles to implementing knowledge management in an organization, especially for technical consultants, who are such a homogenous group with strong professional ties. In their survey of chartered surveyors, Matzdorf and Price (2000) found that the main obstacle to organizational learning was too much emphasis on individual learning.

Using data from the second study, factor analysis based on 18 variables representing frequent obstacles to knowledge transfer and implementing knowledge management initiatives leads to the identification of three factors explaining 48 per cent of the variance. These factors were labeled (F1) Incompetence, (F2) Incentives and support, and (F3) Resistance to intraorganizational knowledge (see Table 8.10). The second factor had an internal consistency just below 0.7 based on Cronbach's a. However, F2 was easy to label and comprises variables that are obviously related to each other.

Table 8.10 Factor analysis of variables representing frequent obstacles to knowledge transfer and implementing knowledge management initiatives. Rotated component matrix with factor loadings.

Variables	Mean	SD	F1	F2	F3	Ca
Training (lack of skills in knowledge management techniques)	5.6	2.0	0.69			0.781
Too little knowledge	3.8	1.8	0.67			
Current culture does not encourage knowledge sharing	5.1	2.1	0.65			
Lack of understanding of knowledge management and its benefits	5.3	1.9	0.62			
Management acceptance (lack of management support and commitment)	5.1	1.9	0.56		0.40	
The organization does not have the right information technology for sharing knowledge	4.5	1.9	0.51			
No reward for knowledge sharing	6.6	1.8		0.65		0.687
Cost (lack of funding)	6.3	2.3		0.61		
Knowledge is difficult to locate	5.9	1.8		0.58		
People want to share knowledge but have no time	7.7	1.5		0.57		
It is difficult to know where to store knowledge	6.2	1.6		0.57		
Efforts wasted through re-inventing the wheel	6.1	1.9		0.54	0.41	
The organization does not have offices that support sharing knowledge	4.7	2.4		0.41		
Knowledge is more effectively shared with outside organizations	4.5	1.6			0.75	0.723
Knowledge from one project is difficult to generalize and use in other projects	5.8	1.8			0.59	
Individuals do not share best practice	5.7	1.9			0.57	
Too much knowledge	3.5	1.7			0.54	
Individuals unwilling to share knowledge	4.4	1.9			0.54	

Extraction method: Principal component analysis. Rotation method: Varimax with Kaiser normalization. Missing values replaced with mean. Rotation converged in 6 iterations. Total variance explained 48%. Kaiser-Meyer-Olkin measure of sampling adequacy = 0.772. Barlett test of sphericity = 619, significance p = 0.000. The number of factors extracted was decided with scree-test.
SD: Standard deviation. (F1) Incompetence, (F2) Incentives and support, (F3) Resistance to intraorganizational knowledge. Ca = Cronbach's a.

The first factor, Incompetence, comprises various obstacles indicating that knowledge is missing. Most of these obstacles have mean values below the average of the scale, which indicates that they are not considered as important obstacles. However, the large standard deviations indicate disagreement among the respondents. Factor two, Incentives and support, is the most interesting factor of the three. All obstacles with high mean values belong to this factor. Similar to factor one the variables in the third factor, Resistance to intraorganizational knowledge, show lower mean values and less importance. Studying the intercorrelations (Kendall's t_b) within each factor, all obstacles correlate significantly at the 0.01 level with eight exceptions. However, lack of time shows little correlation with other obstacles and background variables except lack of funding where a low, but still significant positive correlation was noted. Contrary to expectations, the cluster of managerial obstacles with high intercorrelation that was found in the correlation analysis underlying the presentation in Chapter 7 failed to emerge as a single factor. Instead the five variables representing managerial obstacles were spread over the first and the third factor.

Was the physical facilities perceived to affect knowledge transfer? One of the less prominent obstacles in F2 is related to the offices. Most respondents (54 per cent) agreed that their offices support knowledge sharing, but a sizeable minority (25 per cent) did not. This was almost the opposite of what was expected. Consultants usually have their individual cubicles along a corridor,

and have to leave the room or use the telephone to talk to colleagues[43]. On the contrary, the knowledge management literature emphasizes the advantages of open plan offices and project rooms where people can hear each other, even if they are not involved in the conversation themselves. Only one department studied had an open plan office, and this was combined with cubicles along the perimeter with the open area in the middle only occasionally used or serving as workspace for two or three junior employees. The company where engineering services related to roads and railways were studied had recently moved into a new office when the first (1997-98) study began. They had a traditional layout with cubicles for each consultant and in addition four seminar rooms in the interior of the building, along the corridor. However, one floor up there was a department of electronic engineers with an open plan office area. The road and railway consultants said that the electronic engineers worked in a landscape because they believed that it was easier to learn from one another and to hear what was going on. Among the electronic engineers, furniture was chosen to be easy to move, because the consultants worked in temporary groups which made it necessary to relocate when a project was finished or when a consultant was assigned to another project. On the other hand, the road and railway consultants claimed that their work pattern created a need for keeping a considerable amount of paperbound books, catalogues and other publications in their proximity. Dependence on paper sources of information was thought to reduce their internal mobility in the office.

Another obstacle in F2 is “knowledge is difficult to locate”. Internal knowledge was not yet mapped in any of the companies in early 2000, but there were a few local attempts and experts were identified and recognized at two of the companies. At least two of the firms had recently started initiatives to map all employees’ knowledge in databases available at their intranets. All four companies had databases containing employee CVs, but in two of the companies these were for local use only. These efforts indicate that this obstacle is one that the four companies have started to eliminate more methodically.

It can be concluded that the two most usual obstacles to knowledge transfer and implementation of knowledge management initiatives are lack of time and too many different projects in progress. Both these obstacles are included in the group of obstacles labelled Incentives and support (F2). It is surprising that “lack of time” appears to be unrelated to other obstacles except lack of funding.

[43] At least one example of a growing awareness of how lack of transparency affects knowledge sharing was observed after the 1997-98 study. One department replaced the traditional corridor wall with glazing so that it would be possible to see who was in and who was not.

8.5 Business context, strategy choice and knowledge management

This section aims at discussing organizational and technological conditions in the four companies in the light of the four strategies for technical consultancy companies proposed by Winch and Schneider (1993a), as presented earlier in Chapter 2. These strategies (strong delivery, strong experience, strong ideas and strong ambition) correspond to types of knowledge management efforts, types of learning and types of staff. On the one hand the organization treats design specificity, which is one strategic dimension, according to a functional paradigm where the transfer of knowledge and information is seen as a problem of logistics. On the other hand there is project complexity, another strategic dimension, which often goes together with equivocality and emphasizes the need for a more interpretative approach to transfer of knowledge, an approach that includes both understanding of the customer and of the advanced technical tasks that are implied by the assignment. Any technical consultancy company can be thought of as being organized to make meaning of information in order to reduce equivocality and deal with project complexity, just as it is organized for processing information in order to deal with design specificity. Both dimensions, design specificity and project complexity, contribute to the understanding of knowledge transfer, but depending on which of these two is dominating, the organization should design its knowledge management system more or less according to one of the three strategies that Winch and Schneider claim to be sustainable: strong delivery, strong experience and strong ideas.

8.5.1 Strong delivery

The strong delivery strategy deals with relatively low project complexity and the equivocality of information can also be assumed to be relatively low. Design specificity is low, which means that many design objects can be reused from earlier projects or practices. This reduces the amount of project specific information that has to be acquired and interpreted. At the same time, it is necessary to distribute and store a great volume of standard solutions and best practices. This being a low cost strategy, routines and standard operating procedures will be developed and adhered to; moreover, strong routines for project management are needed.

Considering the situation early in 2000 in the four companies, it is clear that the use of intranets for distributing knowledge and information has increased, but it is still intradepartmental face-to-face communication that is preferred by staff, and the companies appeared to need more efficient methods for distributing information and knowledge across departments.

The age structure in the companies surveyed indicates that there are many older and well-experienced consultants. Although the Swedish technical consultancy companies usually have small differences in salaries depending on age and function of the employees, it will be more expensive to have older consultants performing relatively simple tasks. Work according to routines such as quality assurance was not perceived as easy or personally developing for the individual consultant. Routines and standard operating procedures were only slightly used, if they existed at all. In order to have the consultants to use them more frequently, routines and procedures have to be included in a computer based workflow system and thereby fulfil the requirements of a strong delivery strategy.

However, the companies studied possess considerable skills in project management and there are many project managers available. IT support for performing the technical tasks is also well developed. However, there was no IT support such as databases for standard solutions or construction modules, nor are all project file servers searchable for retrieval of knowledge and information. All these IT investments that could be claimed to be necessary will be expensive and will tax the financial strength of the companies. In the absence of structural change in the industry, in a national or an international perspective, it is unlikely that companies such as these will concentrate on a pure strong delivery strategy.

8.5.2 Strong experience

The second strategy, strong experience, is characterized by high project complexity, and the equivocality of information can be expected to be high. Design specificity is also for this strategy considered as relatively low because the consultants are specialized in the specific type of project and can reuse knowledge from previous projects. This strategy is characterized as grey hair, according to Maister (1982), and requires expertise. In this strategy the age structure of the construction technical consultancy companies fits in better. Many experienced consultants are available but it seems necessary to identify experts clearly and to make their knowledge available throughout the organization. CV databases existed at all four companies in the second study (2000) but only one company had started to produce detailed knowledge maps and to make them available on the intranet.

Although the four companies have made efforts to identify knowledge, this strategy also requires a considerable volume of reference projects for the particular specialization that is practised. At all the four companies, projects are available on local project servers and it is possible to identify projects through reference and project databases. But reusing complex projects also implies that someone who participated in the project should be available to

transfer tacit knowledge as well. This consultant would have to be present physically at the department to which knowledge is transferred since the technology that would support virtual face-to-face meetings had not yet been implemented. Neither was there any groupware available in the companies or other collaborative tools where various consultants could share and edit the same document concurrently.

Although the Swedish technical consultancy companies have a history with periods of a larger proportion of turnover derived from assignments abroad, as outlined initially in section 1.4.1, the 1990s have been marked by a high proportion of domestic projects. However, the recent Swedish market has presented large and technically challenging projects, which means that the experience base is broad. Department managers, when interviewed in the second study (2000), expressed an ambition to engage in more really advanced projects. Thus, it is probable that the studied technical consultancy companies will consider selecting a strong experience strategy.

8.5.3 Strong ideas

The third strategy, strong ideas, deals with complex and unique projects. The high degree of project complexity requires a high level of expertise for reducing the expected equivocality and includes an understanding of both customer needs and of advanced technical tasks. Design specificity is high as well, which means that design objects and specifications cannot be reused. Most of what has to be done must be specified from the beginning and the information load can be expected to be heavy.

Maintaining a strong ideas strategy requires a high proportion of experienced consultants with good communication skills. Meeting people and generating new solutions to new problems require creativity. Both studies, 1997-98 and 2000, showed mean values on the upper half of the scale for the assertions “I often take initiatives to new solutions and work processes at work” and “my work contains elements of new demands and challenges”. The analysis of job characteristics in section 7.3.1 further showed that few consultants believed that much of their work was routine. This indicates that new ideas are felt to be generated in the technical consultancy companies and that there is room for an element of creativity. However, the statement “flexibility and desire to innovate drive the learning process” had a mean value just above the average of the scale. The opportunities to attain a high level of technical creativity may after all be infrequent, given that the four companies lack strong footholds in major foreign markets.

Analysing the IT context of these companies it is easy to find that few tools are in use that enable creativity and exchange of ideas. The company IT

toolbox for the strong ideas strategy would have to include the same collaborative tools as for the strong experience strategy. Again, reference projects are important, although not for reuse in the same way as when following a strategy of strong experience, but rather for use in marketing activities. Neither would databases with standard solutions and best practices play the same primary role under the strong ideas strategy. Since the four companies have been slow in implementing database systems, the strong ideas strategy might be more attractive to follow. On the other hand, unless the Swedish technical consultant companies become more pronouncedly international or create strong alliances including exchange and rotation of staff, the strong ideas strategy will be difficult to adopt across the whole range of their operations. It is more likely that individual departments in a large company that primarily follows a strong experience strategy will be able to compete more successfully by selecting a strong ideas strategy.

8.5.4 Strategy choice, IT investments, business processes and work practices

Regardless of which strategy that is chosen by a company or an individual department, investments in IT tools must support the strategy. Each of the four strategies corresponds to a set of IT tools that enables it, although there are stronger similarities between tool needs generated by the two strategies of strong experience and strong ideas. Obviously, it would be far too expensive to invest in IT tools that would provide the support for all types of strategies. IT investments will have to match the development of business processes, which are intimately linked to IT tools, and work practices, which are slightly more loosely coupled to the toolbox. The more precise managerial implications of this approach will be clarified in Chapter 9.

9 Conclusions

This chapter returns to the research questions as they were initially formulated. The overview of how answers have been found successively through the two sets of questionnaire surveys and interviews with managers from the four companies makes it possible also to identify where the theoretical framework chosen for this investigation might be modified and extended. In doing so, topics for further research as well as implications for the management of technical consulting emerge.

Before looking back at the research questions, the basic set of assumptions underlying the 1997-98 and 2000 questionnaire surveys should be recapitulated. The first questionnaire was generated assuming that individual employees perceive the importance of various sources of learning (or of knowledge acquisition and knowledge retrieval) on the basis of their own work styles, their team styles, department and company styles, their personal motivation and also depending on their age, gender, education, function, and duration of employment with their company.

The second questionnaire broadened the range of dependent variables. Instead of just focusing on knowledge acquisition and retrieval, it was expanded to include choice of knowledge distribution methods, forms of storage and support tools. Moreover, type of knowledge content was brought into the picture.

The analysis presented in Chapter 7 showed that the basic assumptions were mostly confirmed by the responses; in addition, it became clear that a background variable such as age of the individual was much more influential than gender or duration of employment. Furthermore, educational level and function showed up conspicuously as influential explanatory variables. The underlying reason for this pattern is that the task performed depends on the function of a consultant and also, but to a smaller extent, on educational level.

9.1 A reappraisal of the research questions and their answers

As stated in Chapter 3, the first research objective was to study the broad issue of how technical consultancy firms serving the construction industry transfer knowledge.

The first question out of six corresponding to this objective was to verify the existence of and identify reasons for kinds of knowledge that are perceived as crucial to the organization. Results from the second study (2000) indicate that

knowledge about the market and knowledge about similar kinds of projects were considered equally crucial (see Table 7.9). Closely related to market knowledge and felt to be almost as crucial was customer knowledge. By taking each of these knowledge categories and analysing where they were perceived to be stored, it can be concluded that knowledge about the market and knowledge about customers were stored mostly in the heads of people. Knowledge from similar projects was perceived to be stored both in the heads of people and as paper based and electronic records. It was also clear from Chapter 7 that both kinds of knowledge were perceived as being shared and accessible at individual and department levels in the organization. In contrast to less crucial categories of knowledge, the crucial categories were much more related to individuals, who hold knowledge belonging to these categories tacitly in their heads. Nevertheless, there remains the issue of whether knowledge that was shared at a higher organizational level was seen as less crucial just because it was easier to access for a larger number of consultants.

The second question under the first research objective concerned the identification of a strategy or shared vision that would support learning and knowledge transfer. Interviews with managers of the four companies (section 5.2) verified the existence of explicit strategies, formulated as “to cultivate entrepreneurship and knowledge management”, “to build a true knowledge company in which knowledge in structured form is made accessible” or in terms of training, education, leadership development and human and structural capital. However, these strategies remained largely unknown to employees, nor were they sufficiently operationalized to explicitly express a system of knowledge management initiatives so that they could be recognized as a coherent set by more than one of the four interviewed department managers in the second study. Although knowledge management was not expressed in the sense of a process perspective on knowledge, such as a knowledge transfer process, the existence of shared visions was evident from a business process perspective, as analysed in section 5.1. Also, almost all activities in the business processes are intended to assure that the knowledge content of the final output is valid, reliable, and verified. Neither did questionnaire responses, as analysed in Chapter 7, recognize “lack of understanding of knowledge management and its benefits” as one of the more important obstacles to knowledge transfer.

Whether any individual had been appointed as responsible for knowledge management efforts was the third question. Interviews, as described in Chapter 5, revealed that none of the four companies had created a post resembling that of a Chief Knowledge Officer at the time of the last survey, in April 2000. In no case was there any identifiable employee who was particularly responsible for all knowledge management efforts in an entire company. Usually the IT manager or the human resource manager shared the

responsibility for knowledge management issues. However, from the correlation analysis of obstacles related to managing knowledge, discussed in Chapter 7, it can be concluded that there is a group of managerial obstacles with high and significant intercorrelations. This group of obstacles concerns sharing of best practice, unwillingness to share knowledge, management acceptance, lack of understanding of knowledge management issues and the prevalence of a non-supportive organizational culture. Nevertheless, it is also clear that the respondents perceived that this group of obstacles does not form a major barrier. But it cannot be claimed that there was a widespread perception that management in these four companies enables and facilitates knowledge transfer and knowledge management initiatives. Instead of having one single staff function that coordinates knowledge initiatives and measures taken by other staff functions, small-scale coordination was found to be decentralized at the department level where the consultants have to decide how much effort they will put on various initiatives.

Another but closely related issue is the responsibility for managing knowledge according to the business processes. This responsibility falls primarily on the authorized representatives, usually department managers, when they sign documents and drawings before delivery to the customer. Here, the authorized representative performs the ultimate activity in a knowledge transfer process by assuring and certifying the quality, validity and reliability of the information and knowledge that has been externalized in documents and is to be distributed across the company boundary.

Fourth, which methods in the sub-processes of knowledge transfer were preferred by the consultants? The question has been answered in detail for each sub-process in Chapter 8. However, there are a few important general observations that should be underlined. The dominant method for creating and transferring knowledge was by socialization in the daily work, talking to colleagues at the department. Although this might seem to be a trivial finding, there are several explanations for the dominance of socialization. The range of transfer methods was discussed in Chapter 8, where it became clear that the perceived usefulness of a method could be related to two pairs of preferences, as confirmed by both the studies: informality-formality and proximity-distance. The possibility to use interactive communication was also perceived as important by respondents.

It was found that informal methods were chosen because of their availability and the potential for receiving rapid answers. An additional advantage of informality is that questions need not be carefully elaborated when relying on face-to-face discussions with colleagues at the same department. Informal contacts with colleagues in the immediate proximity have turned out to be the most frequently chosen method for transferring knowledge. These internal

interactive communication methods, such as talking to colleagues and helping colleagues, are followed by more introvert methods still based on physical proximity, such as using knowledge from the department library, magazines and the web. External interactive communication methods and training came next. In brief, consultants tended to prefer methods for knowledge transfer characterized by proximity to the source.

The fifth question was related to detecting which enabling conditions and facilitating activities were in place for learning and knowledge transfer. Enablers and facilitators were discussed in Chapter 8 based on results found in chapters 5, 6 and 7. Except for communication and monitoring of the strategy, one of the organizational enabling conditions and facilitating activities that was represented only weakly, probably depending on a perceived lack of formal rewards, all six types of enablers and facilitators were found to be present in the four companies. However, the intensities of various enabling conditions and the reliance on various facilitating activities varied across the range of knowledge transfer sub-processes.

In Chapter 5 it was found that information technology enabled all knowledge transfer sub-processes, though not indiscriminately. However, most of the IT tools considered were basic tools used for carrying out the professional design tasks, and few advanced tools for managing knowledge were found in actual use in the four companies. Looking at the various initiatives to enable and facilitate knowledge transfer taken in the four companies in recent years, it was evident that they had experienced difficulties in translating current principles of knowledge management into everyday practice. Depending on which strategy a company chooses, a particular combination of enabling conditions and facilitating activities has to be put in place. The analysis of strategic choice and knowledge management in Chapter 8 led to the insight that current organizational and technological conditions in the four companies did not correspond fully to any single of the three strategies presented in Chapter 2 for technical consultancy organizations.

The sixth and last question corresponding to the first research objective dealt with finding common obstacles to knowledge transfer and to the implementation of knowledge management initiatives. Ranked in order of importance, lack of time, no rewards for sharing knowledge, and lack of funding were identified as the three major obstacles, according to the questionnaire responses in the second study, which were analysed in Chapters 7 and 8. To put it simply: the Chapter 8 analysis showed that obstacles related to incentives and support were perceived as the most frequent obstacles and that they were strongly interrelated.

Turning to the second research objective, which was to investigate the use of process support tools in the chosen departments, there were only two research questions: what process tools were available and in use, and how were they actually used for the transfer of knowledge? Basically, the analysis of the interviews in the second study (2000, see Chapter 5) produced examples of tools available to employees in the departments from the three first groups of technological enablers: knowledge transfer tools, knowledge mapping tools, and memory tools, as listed earlier in section 2.7.2. Knowledge transfer tools enabling virtual meetings and the fourth group of enabling tools, knowledge combination tools, were not found to have been implemented, regardless of company.

Interviews presented in Chapter 5 indicate that much effort had been spent on web technology in order to provide a stronger technological infrastructure. Between 1998 and 2000, all four companies had focused on creating their common hardware and software platforms. As such a platform is recognized as a solid foundation for other technology based knowledge management initiatives, senior management had prioritized platform creation. Considerable efforts have also been spent on various CAD tools and on introducing company intranets. However, viewed as media for knowledge transfer, IT tools were only considered to be tools for coordination and low level communication rather than exploited for more advanced purposes of knowledge management in the four companies. It is unlikely that top management within the four companies had failed to recognize the potential of IT for knowledge management. The more recent knowledge management efforts typically concerned simple mapping of individual competencies so as to facilitate the internal identification of the right consultants for a project task, rather than focusing on the development of IT tools that could have linked databases, file servers, and mail servers to each other.

Finally, the question as to how these tools are used for knowledge transfer has been split into two parts. To begin with, in Chapter 7 and Chapter 8 the use of technological support tools was the subject of a general discussion. Next, in Chapter 8 how these tools supported the knowledge conversion process was discussed more specifically.

Three technological support tools were used many times a day by more than half of the respondents: telephone, e-mail and standardized IT solutions. These tools were followed by CAD, facsimile, the intranet, the Internet and document management systems. All of these tended to be used on a daily basis. On the intranet, internal services such as administration constituted the most frequently used function. Basic technological tools such as telephone and e-mail were perceived as being the most important. These basic tools were followed in importance by software for preparing technical estimates and

CAD software. While the company intranet appeared to be easily accessible to most of those who needed it, other information systems currently in use were perceived as being neither smart nor integrated.

In the context of IT tools, there was ample reason to point to the effects of age, functional position in the organization and formal education of individuals. Characteristic profiles of groups of individuals appeared, which led to the identification of a strong link between IT medium choice and two sets of attitudes to learning and work. Thus there were strong relations between what was characterized as communicative problem solving, high functional position and the choice of traditional media. The second set of attitudes corresponded to strong relations between what was characterized as emphasis on learning and knowledge, the choice of new media and lower age.

Referring to the knowledge conversion process it was concluded that the technical consultants are quite familiar with the socialization process but much less so with the application of IT tools that enable socialization at a distance. Design tools such as CAD and traditional software for word processing were found to enable the externalization of knowledge. However, much higher participation in discussion groups could have been expected, as well as use of groupware and visual thinking tools. Data mining tools, intelligent agents or associated databases for combination of explicit knowledge were absent. Instead, the four companies appeared to concentrate their efforts on presenting explicit knowledge on their intranets. The last conversion mode, internalization, showed a general lack of enabling tools with a few exceptions such as web based training that was used at two of the companies.

9.2 Seniors, juniors and crossing organizational boundaries

Since the market position of technical consultancy companies as information intermediaries is of long standing and cannot be described as a recent phenomenon, large companies of technical consultants serving the construction industry in a country like Sweden tend to have an employee age pyramid with little slope. From the results of the present investigation several consequences of the age pyramid can be identified. Older consultants function as the front office, handling customers and showing attitudes usually associated with communicative problem solvers. Their choice of information technology tools appears to be less advanced than that of their juniors. Using the two studies, it is difficult to decide whether this is an effect of obsolete knowledge among the senior consultants or, more likely, an effect of having customers that rely on incompatible or less developed information systems in their own organizations. If this is the correct interpretation, it follows from

the trivial observation that information technology used when crossing the boundary between two organizations will be determined by the least advanced technology installed by any of the two.

From the field of project management studies, it is apparent that it is one challenge to introduce project management in an organization lacking the experience of temporary cooperation under precisely defined goals and schedules, and another challenge to enhance project management in an organization long dominated by project work, such as a construction contractor. A similar distinction needs to be made for the implementation of knowledge management in organizations where the primary output is tangible products as opposed to a context where the output of the organization is information and knowledge. Technical consultants belong to this latter type of organization; their core business is the processing of information and knowledge. In this sense, they have always had knowledge management as a top priority and as the core of their operational activities.

When mapping the five-sub-processes of the knowledge transfer process (acquisition, distribution, making meaning, organizational memory and retrieval) onto the business processes identified in the companies, a feature is observed that is conspicuous by its absence from the mainstream literatures on organizational learning and knowledge management. This feature concerns how explicit knowledge leaves the organization. This issue should be thought to be vital for any organization that lives by selling knowledge. Here, the analysis has pointed to the necessity of considering how the certification of information that leaves the organization takes place. In a sense, the assumption of legal responsibility for design documents that are issued by a company can be seen as a procedure for the justification of beliefs held by the organization that is intended to receive the documents. While information and knowledge can flow in and out of organizations, there are few procedures for certifying information and knowledge that cross company boundaries. Technical consultant companies do this by the use of a certified and authorized representative who signs documents and drawings before they leave and thereby certify the content and its correctness. In this limited respect, these technical consultancy companies have well implemented systems for managing information that cross boundaries.

9.3 Generalizing the findings

The validity of the findings can be questioned if we bring in the type of industry served, national differences and size of companies. Whether the findings presented here can be generalized so as to apply also to technical consultants working for other industries, or to foreign companies of technical

consultants serving the construction industry abroad, or to small firms of Swedish technical consultants in the same sector is a set of relevant questions. The age structure in the four companies differs from that found among consultants serving industries that have grown more rapidly or have a short history in the consultancy market. The dependence on paper-based sources and a high proportion of domestic public sector clients may also reduce the potential for broadening the field of application of findings from the present investigation. On the other hand, it is more likely that results from this investigation will applicable to construction consultants outside Sweden, although it should be expected that companies operating in countries with stronger professional identities than in Sweden might be characterized by slightly different attitudes to knowledge, learning and IT tools.

Much of what has been found about the perceived usefulness of various tools for knowledge transfer can be suspected to be limited to large Swedish companies. First there is the choice of studied departments, since these were situated in the two largest cities of Sweden, Stockholm and Göteborg. Compared to smaller offices in smaller cities these departments are large, and according to the interviews, they experience less need to acquire and retrieve extradepartmental knowledge and information than those departments do where only a few consultants share the same specialization. By selecting large departments, a bias may have been introduced in favour of informal methods for transferring knowledge mainly between individuals rather than between departments and organizations. Furthermore, many small offices still lacked access to the same bandwidth for transferring digital data as the larger offices. This can in turn have resulted in an excessive emphasis on digital data transfer and web based communication in the survey findings.

9.4 Suggestions for further research

Technical consultancy firms serving the Swedish construction sector could be seen as organizations facing a geographical dilemma. Whereas investments in information technology and in the development of processes point to advantages in specializing on a global scale, the domestic market is covered by numerous small offices so as to ensure local presence in a country with a low population density. The advantages of local presence are related to the orientation of these organizations towards technologies that modify the built environment, or more in general the physical infrastructure of society. Also, the national language is not one of the major world languages. The ability to provide local services while reaping the benefits of specialization in larger geographical markets can be raised by an appropriate combination of IT tools. An analysis of how organizations deal with this geographical dilemma should also include the effects of the age structure of employees. Principles for

selecting IT platforms for work in organizations such as these could be derived from the joint objectives of global specialization and local presence, while explicitly taking the initial variety of human resources into account. Assuming a future with stronger IT support for mobile work should lead to the prediction of new work patterns for organizations that deliver services oriented towards the physical infrastructure.

In particular, the potential impact of technologies that support virtual meetings in the context of concurrent engineering over a distance should be investigated. Hitherto, the uptake of collaborative technologies has been very slow in this type of professional service organizations. The balance between true face-to-face meetings, internally and with customers, and on the other hand virtual meetings will shift, but which will be the determining factors behind new work patterns in a new equilibrium? Furthermore, it can be hypothesized that the border between real and virtual meetings will be mutually dependent on the physical facilities used for consultancy work. Hitherto, as the present investigation has shown, immediate physical proximity has been a strong determinant of knowledge transfer in these organizations.

9.5 Implications for managers

Just before defining the aim of the present investigation (in section 1.7), it was presumed that technical consultancy firms serving the construction sector would need to achieve world class abilities to manage knowledge, provided that they wished to preserve or reinforce their competitive positions. Given the findings that have been presented here, there are a few major implications for managers of firms such as these.

1. Choose a business strategy and relate the strategy to a knowledge strategy.
2. Assign a Chief Knowledge Officer (CKO) to organize all knowledge management initiatives needed to realize the strategy.
3. Support stronger intraorganizational interpersonal networks.
4. Improve career paths for younger consultants.
5. Reduce the need for intergenerational socialization by using archives.

The first implication for managers, *choosing strategy*, translates into a compromise between utilizing current knowledge within the organization and the possibilities to acquire knowledge that is needed to realize a business strategy. However, the discussion in Chapter 8 showed that it is unwise to create intraorganizational conditions that enable and facilitate multiple strategic directions simultaneously. It may as well be inefficient to determine one single business strategy for an entire consultancy group. Instead the

strategy choice at group and company level has to be generic in order to support several but related strategic directions that could coexist at lower organizational levels. This enables decentralized implementation of knowledge strategies at subsidiary, division and department levels within a larger consultancy group. It should be noted that the alignment of business and knowledge strategies corresponds to an iterative process if IT investments needed to implement a particular knowledge strategy are predicted to reach a level where the business strategy must include specialization in larger geographical markets than before to ensure financial viability.

Assign a Chief Knowledge Officer (CKO) to organize all knowledge management initiatives needed to realize the strategy is the second implication for managers. Today, responsibility for knowledge management seems ultimately to fall on the authorized company representative for each individual assignment. Having a single manager appointed to the position as a Chief Knowledge Officer or Knowledge Manager is a phenomenon seen in other industries, and such managers will be able to control the relation between centralized and decentralized knowledge initiatives. Creating the position of a CKO should also raise the potential for coordination and integration of human resources management, IT management and systems for quality and environmental management.

Support stronger intraorganizational interpersonal networks is the third managerial implication. It was found that the consultants learn less from colleagues at other departments and offices than from people from other companies, participating in the same project organization, with whom they are in daily or weekly contact. The current culture of learning appears to enable intraproject learning rather than organizational learning.

One method to increase the internal transfer of knowledge, which should be seen as a main justification for being a large consultancy group, is that managers should create an environment where individual consultants get to know and learn from each other across boundaries between specialized departments. Personal networks are important for knowledge transfer and recently hired consultants need to form such networks as quickly as possible. One way of doing this is by an increased emphasis on job rotation during the first year of employment. The evolution of new design tools and the implementation of other types of new and advanced IT support might change the traditional view of separate professions, disciplinary division of labour and patterns of specialization according to technologies. Broader personal networks should be an asset when radical reorganization of work is prompted by the emergence of more efficient IT tools. Strong interdisciplinary personal ties and contact with consultants from other specializations should contribute to flexibility and creative questioning of the inherited structures.

Improve career paths for younger consultants, the fourth managerial implication, is related to recruitment. Older consultants, as the surveys show, tend to be more client-oriented and communicative, but also less willing to work with new systems, use new media for communication and to take on more responsibility. However, interviews with managers indicated that the problem of knowledge erosion was greater when younger consultants left the organization. Younger consultants are often better educated and more mobile than their older colleagues. Many of the younger consultants with a high potential as future project managers and line managers may leave prematurely. The development of knowledge strategies should support the redesign of career paths for younger employees.

Reduce the need for intergenerational socialization by using archives. The fifth implication for managers is closely related to the fourth implication. Traditionally, consulting engineers have stayed at the same company for decades, an employment pattern that goes along with a long process of transferring knowledge by socialization. Younger consultants have learned from their older colleagues. Stable or declining demand for services has also been reflected in the hierarchies within these companies, reducing the need to promote less experienced consultants to project managers. Market turbulence generated directly and indirectly by the evolution of new and more advanced IT tools necessitates new ways of organizing work and new careers. At the same time, new IT tools also provide the means for structuring and storing knowledge so that business processes can be supported much more efficiently by explicit knowledge. The creation of new archives in a wide sense, containing explicit knowledge, will thus offer an important opportunity to reorganize business processes while also contributing to recruitment and new careers within companies.

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Appendix 1. The 1997-98 questionnaire

Gender

0	1
Female	Male

Age

1	2	3	4	5	6	7
Younger than 20 years	20-25	26-30	31-40	41-50	51-60	Older than 60 years

Function

1	2	3	4
Assistant consultant engineer	Consultant engineer	Project manager	Department manager

Number of years that you have had the same kind of job (tasks)

1	2	3	4	5
0-3	4-6	7-10	11-15	More than 15 years

Number of years that you have been employed in this company

1	2	3	4	5
0-3	4-6	7-10	11-15	More than 15 years

Education

1	2	3	4	5
Elementary school	High school, upper secondary school	University degree	Master degree in civil engineering or similar	Licentiate of engineering or PhD

Tasks that you do most often

1	2	3	4	5
Feasibility studies	Conceptual design	Detailed design	Inspection	Administration

Questions in theme 1-5

Number	Question or assertion	Scale
1. Organizational and environmental conditions for competence development and learning (mark on the ten grade scale to what extent you agree)		
1	I plan my work	Likert style
2	My team plan our work in the projects	Likert style
3	I or my team determine if my or our work is right done	Likert style
4	There are time to learn things important for my work	Likert style
5	I or my team have opportunity to take back work is someone in the team has been away.	Likert style
6	Much of my work is routine	Likert style
7	I use much of my knowledge in my work	Likert style
8	Most of what I do contains a good mix of difficulties	Likert style
9	My work contains elements of new demands and challenges	Likert style
10	My work is varied and alternated	Likert style
11	I contribute to solving most problems that occur in my job	Likert style
12	I often help others to solve problems that occur at work	Likert style
13	I learn a lot by participating in internal courses	Likert style
14	Which internal courses do you have an opportunity to apply for?	No
15	Which internal courses have you participated in during the last two years?	No
16	I learn a lot by participating in external courses	Likert style
17	Which external courses do you have an opportunity to apply for?	No
18	Which external courses have you participated in during the last two years?	No
19	I learn things I can use in my work at internal professional seminars	Likert style
20	I use information from the company library in my work	Likert style
21	I learn by reading professional journals and magazines	Likert style

22	I learn a lot by reading scientific journals	Likert style
23	I learn by reading books	Likert style
24	I'm expected to share knowledge and experience with colleagues at my company	Likert style
25	I'm expected to report on knowledge I have learned at a course/training to my colleagues	Likert style
26	We help and support each other at work	Likert style
27	The tools (resources) work well and are appropriate	Likert style
28	Suggestions and proposals are taken seriously at my company	Likert style
29	New ideas and initiatives are encouraged	Likert style
30	We are rewarded for learning at my job	Likert style
31	There are good opportunities to make a career by doing a good job	Likert style
2. Use of competence (mark on the ten grade scale to what extent you agree)		
32	I get a lot done at work	Likert style
33	My work is meaningful and I feel motivated	Likert style
34	I'm involved in my work and often do more than expected	Likert style
35	I'm loyal to my company and give up my private life for work	Likert style
3. Potential for competence development (mark on the ten grade scale to what extent you agree)		
36	Most changes at work are stimulating and provide new opportunities	Likert style
37	I want to learn more at work	Likert style
38	I want more responsibility at work	Likert style
39	I want to have a more qualified job content	Likert style
40	I want to work more with new systems and methods at work	Likert style
41	I often take the initiative to new solutions and work processes at work	Likert style
42	I'm interested in trade associations related to my work	Likert style
43	In which trade associations are you a member?	No
4. Methods for competence development and learning (mark on the ten grade scale to what extent you agree)		
44	I learn things I can use in my work by participating in training and courses	Likert style
45	I learn in my work by trying different tasks and by planned supervision	Likert style
46	I learn a great deal I can use in my work by experience	Likert style
47	I use my experience from previous projects as a best practice when I participate in a new project	Likert style
48	I use experience from my company's previous projects that I have learned from others as best practice when I participate in a new project	Likert style
49	The project team (if there is one) within the company use previous projects as best practice when they work with a new project	Likert style
50	I learn by helping colleagues and others	Likert style
51	I learn things I can use in my work by daily conversations with colleagues	Likert style
52	I learn things I can use in my work by talking to colleagues in my company but outside my office/department	Likert style
53	I learn things I can use in my work from contact with superiors	Likert style
54	I learn things I can use in my work from contact with clients	Likert style
55	I learn things I can use in my work from contact with users	Likert style
56	I learn things I can use in my work from contact with suppliers	Likert style
57	I learn things I can use in my work from contact with other technical consultants	Likert style
58	I learn things I can use in my work from contact with architects	Likert style
59	I use knowledge and information from the intranet in my work	Likert style
60	I use knowledge and information from the Internet in my work	Likert style
61	I use the quality assurance manual in my work	Likert style
62	I think it is easy to use the routines in my company's quality assurance manual	Likert style
63	I think routines and checklists in my company's quality assurance manual are valuable resources for me in my work	Likert style
64	I believe it is personally developing to work according to the routines in my company's quality assurance manual	Likert style
65	I believe my company's customers are positive about how we assure quality	Likert style
66	I believe quality audits are good opportunities for learning	Likert style
67	I consciously try to produce an output with good environmental performance	Likert style
5. Sensitivity for knowledge erosion (mark on the ten grade scale to what extent you agree)		
68	If I had a chance to take a similar job at another company, I would do so	Likert style
69	If I had a chance to take another job, I would do so	Likert style
70	I will probably work at the same office in five years	Likert style
71	I will probably still work at the same company in five years	Likert style

Appendix 2. The 2000 questionnaire

Gender

0	1
Female	Male

Age

1	2	3	4	5	6	7
Younger than 20 years	20-25	26-30	31-40	41-50	51-60	Older than 60 years

Function

1	2	3	4
Assistant Consultant engineer	Consultant engineer	Project manager	Department manager

Number of years that you have had the same kind of job (tasks)

1	2	3	4	5
0-3	4-6	7-10	11-15	More than 15 years

Number of years that you have been employed in this company

1	2	3	4	5
0-3	4-6	7-10	11-15	More than 15 years

Education

1	2	3	4	5
Elementary school	High school, upper secondary school	University degree	Master degree in civil engineering	Licentiate of engineering or PhD

How often do you perform the following kind of tasks?

	1 Often	2 Sometimes	3 Never
Feasibility studies			
Conceptual design			
Detailed design			
Inspection			
Administration			

Questions theme 1-5

Number	Question or assertion
1. Purposeful attempts to transfer knowledge (mark on the ten grade scale to what extent you agree)	
1.1	We send people to conferences in order to acquire knowledge
1.2	We encourage reading in order to acquire knowledge
1.3	We interview new employees in order to learn from their unique knowledge when they start to work at our company
1.4	We supply knowledge to our clients to allow them to be better players in the value chain
1.5	We use knowledge obtained from our clients in order to improve our operations
1.6	We supply knowledge to suppliers to allow them to be better on their operations
1.7	We use knowledge obtained from suppliers in order to improve our operations
1.8	Our company provides knowledge to other actors in the construction sector, i.e. other consultants, contractors and manufacturers
1.9	We encourage job rotation and working with different tasks in different projects in order to acquire knowledge
1.10	We encourage initiatives and experimenting in order to acquire knowledge
1.11	I have been involved in R&D projects where I have learned things useful for my work.
1.12	We use continuous improvement processes in order to acquire knowledge
1.13	The company has a corporate story book
1.14	We try to encourage people to question assumptions in order to acquire knowledge
1.15	We try to encourage open dialogues in order to acquire knowledge

1.16 Our staff are encouraged to talk about their own work and the business in general
1.17 We are encouraged to participate in knowledge communities we choose ourselves
1.18 We have knowledge communities that help each other
1.19 The company has a way of minimizing knowledge erosion

2. Perceptions of how useful various methods/sources are for knowledge transfer (mark on the ten grade scale to what extent you agree)

2.1 I use my experience from previous projects as best practice as I participate in a new project
2.2 I use experience from previous projects that I have learned about from others as best practices when I participate in a new project
2.3 I learn by helping colleagues and others
2.4 I learn in my work by trying different tasks and by planned supervision
2.5 I believe quality audits are good opportunities for learning
2.6 I learn by taking internal courses
2.7 I learn by taking external courses
2.8 I learn by visiting internal conferences (skråträffar, teknikområdesträffar)
2.9 I learn by participating in the weekly briefings at my department
2.10 I learn by participating in staff mentoring arrangements
2.11 I learn by talking to colleagues at my office/department
2.12 I learn by informal talking to colleagues at my office/department. For example at coffee breaks, in the corridor and at lunch
2.13 I learn by talking to colleagues in my company but outside my office/department
2.14 I learn from interaction (credit and criticism) with clients
2.15 I learn from interaction (credit and criticism) with users
2.16 I learn from interaction with other technical consultants
2.17 I learn from interaction (credit and criticism) with suppliers
2.18 I learn from interaction (credit and criticism) with architects
2.19 I'm interested in trade associations related to my work
2.20 I learn by participating in discussion groups on the Internet (external)
2.21 I learn by participating in discussion groups on the intranet (internal)
2.22 I search the Internet for knowledge I need
2.23 I search our intranet for knowledge I need
2.24 I learn by reading professional journals and magazines
2.25 I learn by reading books
2.26 I learn by reading internal publications and lessons learned
2.27 I learn from using routines and checklists in my company's quality assurance system
2.28 I use knowledge from the department library in my work
2.29 I find compact discs from building material suppliers/manufacturers useful in my work
2.30 Compact discs or Homepages are more useful than paper catalogues

3. Access to knowledge (mark on the ten grade scale to what extent you agree)

3.1 I have access to knowledge holders both inside and outside the company
3.2 Geographically dispersed knowledge is integrated in the corporate memory and made available within the company
3.3 Lessons learned from different projects are made easily accessible to all in the company
3.4 The company has a well implemented suggestion system

4. Distribution of knowledge to different hierarchical levels (mark the highest level where you find that you share the following knowledge categories in your company)

4.1 Knowledge maps - who knows what
4.2 Methods and processes
4.3 Best practice and know-how
4.4 Knowledge from similar projects
4.5 Internal organization and management information and knowledge
4.6 Own services mix
4.7 Regulatory environment
4.8 Emerging trends
4.9 Competitors (what they know and do)
4.10 Customers (what they want, local standards, whom they work with)
4.11 Own markets

5. Knowledge categories assumed to be crucial within the company (mark on the ten grade scale at which degree you find the following knowledge categories as crucial for your company)

5.1 Knowledge maps - who knows what
5.2 Methods and processes
5.3 Best practice and know-how
5.4 Knowledge from similar projects
5.5 Internal organization and management information and knowledge
5.6 Own services mix
5.7 Regulatory environment
5.8 Emerging trends
5.9 Competitors (what they know and do)
5.10 Customers (what they want, local standards, whom they work with)
5.11 Own markets

Theme 6: Organizational memory. Mark for each knowledge category where you perceive that this knowledge is stored. Each knowledge category can be stored in several storages.

Knowledge category	People	Theories of action	Ecology	Structure	Culture	Formal processes	Core Competence	Policies	Paper, Records	Electronic, Records	Expert systems	External	Don't know
6.1 Knowledge maps - who knows what													
6.2 Methods and processes													
6.3 Best practice and know-how													
6.4 Knowledge from similar projects													
6.5 Internal organization and management information and knowledge													
6.6 Own services													
6.7 Regulatory environment													
6.8 Emerging trends													
6.9 Competitors													
6.10 Customers													
6.11 Own markets													

Questions in theme 7-14

Number	Question or assertion
7. Use of the intranet (mark on the ten grade scale how often you use the following functions on your intranet)	
7.1	Knowledge maps - who knows what
7.2	Methods and processes
7.3	Best practice and know-how
7.4	Knowledge from finished projects
7.5	Knowledge from projects in progress
7.6	Document management
7.7	Internal services such as administration
7.8	Competitors (what they know and do)
7.9	Customers (what they want, local standards, whom they work with)
7.10	Own markets
8. Willingness to manage knowledge (mark on the ten grade scale to what extent you agree)	
8.1	I want to learn more at work
8.2	I want to work with new systems and methods
8.3	I want more responsibility at work
8.4	I want to have a more qualified job content
8.5	Most changes are stimulating and provide new opportunities
9. Organizational conditions for managing knowledge and perceptions of the use of knowledge (mark on the ten grade scale to what extent you agree)	
9.1	I use much of my knowledge in my work
9.2	I plan my work
9.3	Much of my work is routine
9.4	My work contains elements of new demands and challenges
9.5	I contribute to solving most problems that occur in my job
9.6	My work is meaningful and I feel motivated
9.7	There are good opportunities to make a career by doing a good job
9.8	I'm involved in my work and often do more than expected
9.9	I'm loyal to my company and give up my private life for my work
9.10	I get a lot done at work
9.11	I often help others to solve problems that occur at work
9.12	I'm expected to share knowledge and experience with others at work
9.13	I often take new initiatives in my work
9.14	The organization encourages and facilitates knowledge sharing
9.15	A climate of openness and trust permeates the organization
9.16	Flexibility and desire to innovate drive the learning process
9.17	Employees take responsibility for their own learning
9.18	There are opportunities to learn things important to my work
9.19	We help and support each other at work
9.20	We are rewarded for learning at my job
9.21	Our training budget is adequate or better than adequate

10. To what extent various technical process support tools are used (mark on the ten grade scale how often you use the following technological process support tools)

10.1 Internet (WWW)
10.2 Intranet
10.3 E-mail
10.4 Mail (traditional)
10.5 Telephone
10.6 Facsimile
10.7 Document management system
10.8 Group-ware
10.9 Video conferencing
10.10 Web conference with pictures (intranet as well as Internet)
10.11 Telephone conference
10.12 Project management software
10.13 Software for technical estimations
10.14 CAD software
10.15 Decision support
10.16 Standardized IT solution (hw/sw)
10.17 Knowledge maps - who knows what
10.18 Discussion lists

11. The importance of various technical process support tools (mark on the ten grade scale how important for your work you find the following technological process support tools)

11.1 Internet (WWW)
11.2 Intranet
11.3 E-mail
11.4 Mail (traditional)
11.5 Telephone
11.6 Facsimile
11.7 Document management system
11.8 Group-ware
11.9 Video conferencing
11.10 Web conference with pictures (intranet as well as Internet)
11.11 Telephone conference
11.12 Project management software
11.13 Software for technical estimations
11.14 CAD software
11.15 Decision support
11.16 Standardized IT solution (hw/sw)
11.17 Knowledge maps - who knows what
11.18 Discussion lists

12. Perceptions of various technological process support tools (mark on the ten grade scale to what extent you agree)

12.1 Technology links all members of the company to one another
12.2 Technology links all members of the company to all relevant external publications
12.3 Technology creates an institutional (corporate) memory that is accessible to the entire company
12.4 Technology that supports communication is rapidly placed in the hands of employees
12.5 Information systems are real-time (updated information only)
12.6 Information systems are integrated and smart (talk to each other)
12.7 Technology supports communities of knowledge sharers
12.8 Our intranet is easily accessible to all staff who need it
12.9 The tools (resources) work well and are appropriate
12.10 I have the process supporting tools (resources) I need

13. Perceptions of the organization's knowledge management objectives (ambition levels), (mark on the ten grade scale to what extent you agree)

13.1 Standardization of knowledge in the form of procedures/protocol
13.2 Facilitation of the reuse of knowledge about operations
13.3 Transforming individual knowledge into collective (organizational) knowledge
13.4 Combination of customer related knowledge and internal know-how
13.5 Acquisition of new knowledge from external sources
13.6 Generation of new knowledge inside the organization
13.7 Establishing a reputation on the market as a best practice company

14. The most common problems in creating and transferring knowledge (mark on the ten grade scale to what extent you agree)

14.1 People want to share knowledge but have no time
14.2 Efforts wasted through re-inventing the wheel
14.3 No reward for knowledge sharing
14.4 Knowledge is more effectively shared with outside organizations
14.5 Knowledge is difficult to locate
14.6 It is difficult to know where to store knowledge
14.7 Knowledge from one project is difficult to generalize and use in other projects
14.8 Individuals do not share best practice
14.9 Individuals unwilling to share knowledge
14.10 Management acceptance (lack of management support and commitment)
14.11 Lack of understanding of knowledge management and its benefits

14.12	Current culture does not encourage knowledge sharing
14.13	Too little knowledge
14.14	Too much knowledge
14.15	The organization does not have the right information technology for sharing knowledge
14.16	Training (lack of skills in knowledge management techniques)
14.17	The organization does not have offices that support sharing knowledge
14.18	Cost (lack of funding)