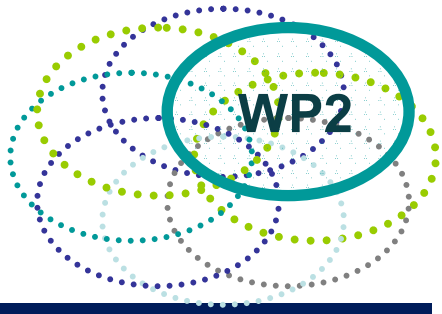
A Systematic Analysis of Knowledge practices in other sectors:
lessons for construction

September 2003



Knowledge Management for
Sustainable Construction Competitiveness

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1. EXECUTIVE SUMMARY

This report represents an analysis of knowledge processes in Construction and other chosen sectors, in order to inform knowledge management practice in the construction industry. It is based on original research conducted in 2003.

The report acknowledges that the transfer of lessons learned between sectors requires an awareness of differences between these contexts. Here Construction is compared with Software & Computing Services, Manufacturing and Agriculture.

The approach adopted emphasises the value of addressing the complexity of knowledge, while acknowledging the challenges this poses. There is an emphasis on process and capability, as well as resources and assets.

The research assumes that key knowledge processes occur informally, as well as formally under a 'knowledge management' (KM) banner. This assumption was supported by the findings.

The companies studied were selected to provide a range of different organisational sizes and types in each sector.

Informal knowledge processes were found in all sectors. Formal KM had been introduced in all sectors with the notable exception of Agriculture.

Knowledge acquisition through experience was particularly emphasised in Construction, but was also important in sectors such as Agriculture. In all sectors, organisational capacity is dependent upon on formal education and training being augmented by practical experience, but this crucial process was generally not seen as central to formal KM.

The sources of knowledge and information drawn upon in solving specific problems and generating ideas varied between sectors. Software developers search the internet widely, manufacturing firms rely on internal expertise and farmers on external networks. Construction firms favour internal knowledge sources or knowledge sources within their supply chain. The findings indicate that small firms are more likely to rely on external knowledge sources.

For more general knowledge acquisition, the farmers, manufacturing firms and IT companies used extensive external knowledge networks. The manufacturing firms particularly tended to use wide external knowledge networks for strategic objectives, such as moving into new markets.

The larger firms had invested considerable resources in formal KM projects. KM systems common to large organisations across the sectors focus on communication and knowledge sharing, and systems that facilitate expertise location with the aim of knowledge re-use. A list of factors that were critical to the success of formal KM initiatives is listed in the conclusions.

2. Introduction

This report is one of a sequence of reports constituting the deliverables of the project 'Knowledge Management for Sustainable Construction Competitiveness' funded by the DTI *Partners in Innovation* programme (project # CI 39/3/709). The overall aim of the project is to investigate the challenges and opportunities associated with the management of knowledge resources and capabilities in the construction sector.

The planned outputs of the study include reports for construction organisations and policy makers, fact sheets, training materials for workshops, seminars and CPD purposes; journal and conference articles. The dedicated web-site for detailed information on the study and for disseminating some of the study outputs is: http://www.knowledgemanagement.uk.net

This report has been prepared approximately half-way through this 2-year project which commenced in July 2002. The contribution of this report and the work package it represents (WP2) is to provide insights for the construction industry based on lessons from other chosen sectors, coupled with a comparative analysis of the construction industry compared with these other sectors. To this end, the report presents findings from original empirical research conducted in 2002-3.

2. 1. Purpose & context of report

This report is the major deliverable from Work Package 2, focusing on a systematic analysis of knowledge processes in construction and other chosen sectors, in order to inform knowledge management practice in the construction industry. It should of course be seen as complementing the other deliverables from this project, and it also complements other related PII project reports, for example the Taylor Woodrow 'Review of Existing Knowledge Management Research & Practices' (Blake & Sheehan 2002).

For reasons of brevity this report seeks to avoid repetition of other reports, and focuses on presentation of new empirical data rather than reviewing existing literature. However the approach to 'knowledge management' adopted here differs in some significant ways from other approaches, as explained in the *conceptual framework* section below.

The report is predicated on the assumption that it is likely that the construction industry may benefit from an understanding of knowledge practices in other sectors. However, we do not assume that 'best practice' in one sector can be simply reproduced in other sectors. Industrial sectors have different cost bases, innovation dynamics, skills and labour-intensity, and a wide range of other divergent characteristics. The portability of lessons learned depends on understanding the different contexts within which knowledge processes occur, and how these contexts relate to construction.

2. 2. Conceptual framework

The approach adopted in this research begins with the awareness that the subject of *knowledge* presents conceptual and practical challenges to organizations, policy makers and indeed researchers. The fact that the 'Knowledge Management' bandwagon has emerged only since the mid-1990s hints strongly at underlying dilemmas and fundamental issues. On the one hand the apparent lack of interest in knowledge management pre-1995 suggests that either the subject was thought unimportant or unmanageable. On the other hand it is patently obvious that knowledge processes occurred in organizations pre-1995, and in one way or another were 'managed', whether or not these processes were formally labelled 'Knowledge Management'. Indeed, much of the current interest in knowledge management focuses on the *discovery* of existing informal knowledge processes such as storytelling, and existing knowledge structures such as informal communities of practice, rather that the design of new processes or structures. (Chataway *et al* 2003, Quintas 2004).

For this project both informal knowledge processes and formalised 'Knowledge Management' initiatives are taken into account. We also seek to adopt an approach that attempts to deal with *knowledge*, rather than any proxies, such as information. Many accounts of 'Knowledge Management' default to a focus on information management. Such a view underestimates the richness of the subject of knowledge, and the opportunities a knowledge focus offers for re-thinking business processes.

Whereas certain types of knowledge can be codified and treated as information, much knowledge is personal, being based on experience and reflection, and remains tacit (Polanyi 1958, 1966). Conversely, knowledge also has a social dimension, being created and shared in social groupings, within which tacit knowledge sharing may often occur (Brown & Duguid 1991). Related to its social nature, knowledge is also created in specific contexts, and is to varying degrees 'situated' (Lave & Wenger 1991) or context specific, and may be 'sticky' and difficult to transfer or share (von Hippel 1994). As noted above, this reduces the potential for the simple and costless transfer of lessons learned between contexts, such as companies or industries.

Many approaches to knowledge management emphasize the capture and processing of knowledge resources or assets (or intellectual capital) that the organization already possesses. A further aspect of the approach adopted here is to focus on knowledge processes and dynamic capabilities as well as knowledge resources. An emphasis on organizational processes such as knowledge creation and sharing provides a greater indication of dynamic capabilities.

This research is also informed by the new focus on practitioner knowledge emphasised by Gibbons *et al* (1994). In *The New Production of Knowledge*, they identify a shift in modes of knowledge creation from mode 1 to mode 2. Mode 1 knowledge is produced in institutions, is disciplinary, with a hierarchical control system through peer review, and an emphasis on

generating codified knowledge which is transferable. Mode 1 knowledge grows cumulatively, is stored in libraries and forms the content of university syllabuses and professional qualifications. In contrast, mode 2 knowledge is created in the context of application – it results from practice. It is transient, and often unrecorded. It is transdisciplinary, and the capability to produce it is widely diffused. Gibbons *et al* argue that mode 2 has hitherto been under-valued, and also that it is increasing in importance.

A final conceptual theme focuses on cross-boundary knowledge processes, and particularly the need for organizations to acquire knowledge form external sources. Arguably no firm has ever been independent in knowledge terms (Richardson 1972), and today all organizations are likely to be increasingly dependent on external sources of knowledge. The capability to track, make sense of, understand and assimilate externally sourced knowledge is known as *absorptive capacity* (Cohen and Levinthal 1990). The skills required to absorb knowledge include techniques of sourcing, sense-making and learning.

The conceptual framework of this research therefore emphasises knowledge capabilities or processes as well as resources, takes account of informal knowledge processes as well as formal knowledge management, values practitioner (or mode 2) knowledge, considers context, and addresses the issue of absorptive capacity. It also acknowledges the richness and complexity of the subject of knowledge, whilst recognising that firms need to address practical issues. Thus we focus on a number of knowledge processes occurring within and between firms:

- creating / generating / producing knowledge
- communicating, sharing knowledge
- searching / sourcing knowledge
- synthesising / transforming / combining knowledge
- capturing / codifying / storing / classifying knowledge
- mapping knowledge or knowledge proxies
- applying and re-using knowledge

2. 3. Research Design/ Methods

Work Package 2 began with a thorough review of the relevant literature on the challenges associated with knowledge management in general, and in construction in particular. The conceptual framework was developed, and preliminary discussions held with practitioners and other researchers. The work package drew on complementary developments in Work Packages 1 and 3, and the outcomes of the User Requirements Workshop held in November 2002.

The original empirical research component focused on 43 interviews conducted in 2003. Sample firms were selected from chosen industrial sectors: software and computing services, manufacturing, farming and construction. Sample firms were chosen to provide a range of

different sizes, specialisms and different levels of knowledge management implementation. The sample is not claimed to be a structured, representative sample of each sector.

Interviews were conducted using a semi-structured approach. The need to address informal as well as formal knowledge processes precluded any initial focus on 'Knowledge Management' per se. Instead, interviewees were asked about knowledge processes that occur naturally, such as the sources of knowledge for problem-solving and creative work. This device sought to invite discussion of informal knowledge processes as well as those that may be considered formal knowledge management.

2. 4. Report Structure

The following sections of the report are structured under industrial sector headings. Each sector and the research participants are briefly described, prior to presentation of the research and its findings. The final section of the report draws cross-sectoral comparisons, and provides conclusions.

3. SOFTWARE & COMPUTING SERVICES SECTOR

3. 1. Description of sector & research sample

The Software and Computing Services sector comprises the Services and software firms that provide information and communication technologies (ICTs) to all other sectors of the economy. The sector does not include the manufacture of computer hardware, nor telecommunications, but is nevertheless a significant component of the economy. The UK Software and Computing Services sector was valued at £20.4 billion in 2001, and was growing at 5.4% per annum (SCS, 2003). The industry employs approximately 902,000 people in the UK, in over 130,000 firms, with around 20 of the largest firms accounting for a significant share of the market.

The companies that we interviewed in this sector reflected a range of the businesses operating in the Software & Computing Services sector. One was the UK subsidiary of a major player in global markets with revenue in 2002 of $81,186 million and employees numbering 300,000. Globally, it produces and provides computer software, computer hardware and computer services (such as Network Computers, PCs, Notebooks, Servers, Workstations, Consulting, e-Business and Systems Integration services), Software (Database Management, Internet Applications) and Storage (Hard Disk Drives, Storage Systems and Software). For this study we focused on the UK subsidiary that is in the computer software and services sector.

Another was a small business, operating a successful national operation with 9 staff. It offers Project Management Services, System Design Services, Software Development Services, System and Middleware Software Provision and Licensing, Systems Integration and Data Migration Services, Training Services and Managed Services.

A further 2 businesses were self-employed IT consultants. One consultant specialises in writing software, for example databases to sit behind websites. Another provides workstation support (applications, peripherals, trouble-shooting) and provides advice and technical expertise for the deployment of PCs, networks and other IT systems. He also creates bespoke systems. As a designer of print and web-based media, he designs user-interface of websites.

There are some similarities between the IT and Construction industries that have resulted in the industries being compared before. The most striking of these is the project-type organisation of their activities. It can be argued that the difficulties of operating on the client's site, of project team formation and of re-absorbing learning from the project to the originating

organisation are shared. Another point of comparison in the past has been parallels drawn between building design and software design.

3. 2. Informal knowledge processes

Those that we interviewed in the Software & Computing Services sector utilised a wide range of* external *sources, which they usually accessed through the internet, to assist them with creative work or problem-solving.

Although one individual found ideas came to him through brainstorming or, in one instance, through a conversation featuring a misunderstanding, it was often acknowledged by others that their ideas are rarely original. When asked where new ideas came from, one IT consultant who also did creative, graphic design work, said, 'Frequently from things you've seen before.' The Director of Product Realisation in a software consultancy said, 'Keeping up to speed on what's possible; from the vendor – technical seminars from Microsoft give you an idea of what kind of technologies might be out there; continuous investment in training – it is often so easy to do something once you know how, that it is easier than figuring something out yourself.' His Managing Director said, 'From looking for existing bits and applying them. The skill is in integrating those bits. For product ideas we look to Microsoft first. Copy. Plagarise. We look at competitors' systems – find information on the system, look at clients' products. Buy it and take it apart. See how it works.'

When problem-solving, those that we interviewed in Software & Computing Services used a wide variety of references. These included,

- 'Technical documents from bookshops'
- Buying books or 'browsing bookshops
- 'newsgroups' (internet)
- 'discussion groups' (internet)
- 'Trade materials (eg CDs with code samples)'
- 'Source code from Microsoft site'
- 'Product literature'
- 'Trade associations'
- 'White papers'
- 'Open-source software – Linux'
- 'Groups of advocates' (on the internet)
- 'Gurus who put source code on the internet to prove they're clever'
- Microsoft events
- Bullet boards

Table 1. Examples of references used for problem-solving in Software & Computing Services

A similarly extensive list of references was described for dealing with business matters,

• 'the internet'	• User Groups
• 'Federation of Small Businesses for low-cost services like insurance'	• 'We have internal resources like SAGE, MS Office and a 'Concerns & Improvements system'
• 'Government [web]sites for information on regulations'	• 'Trafford Park Business Forum'
• Consultants	• 'Local universities'

Table 2. Examples of references used for dealing with business matters in Software & Computing Services

Similarly, although one individual cited 'experience' as his knowledge map, knowledge mapping was often undertaken through the internet, or more specifically through Google (an internet search engine) and on occasion, a couple of specialist websites, Planet Source Code and Code Guru. Technical white papers and technical CDs were also used.

Knowledge capture was systematised in all cases except one, but in* business *systems, rather than* knowledge management *systems.

With the exception of one of the independent IT consultants, knowledge capture was systematised, although this did not necessarily mean having a bespoke system. One IT consultant, who was presently mainly writing software such as databases, used Microsoft Word to document information on clients, software and objects. Client files included information on who he was working for and why (ie what their problem was). These files could be a reference for problem-solving or for conflict resolution. Project files recorded what the project was, why he's doing it, what he's done, progress to date, thoughts & ideas for the future, potential clients, bugs and problems to solve. Object files were files about a particular thing eg an internet server configuration is incredibly complicated and worth documenting.

The software consultancy with nine employees used more sophisticated software, specifically designed to track the technical development of products (such as a description of the original problem, how the source code was designed, how the code solves the problem) and all aspects of the business (for example, policies, procedures, company contacts, communications with clients and links to documents, letters and e-mails and concerns and improvements, that is, new business opportunities, potential problems arising, suggestions for improvements and so on).

The Managing Director emphasised that information capture and re-use was key to the firm's competitiveness: '…efficiency. We can't afford to waste time so we need efficient use of information - fast searches of databases, queries, reports and to act on the information. For example, we need to be able to identify a trend and do a mailshot. We're looking to capture information and re-use it.' However, whilst it was recognised that the systems had a knowledge management function, they were understood as being business systems, rather than knowledge management systems. The multinational company subsidiary, on the other hand, had numerous tools and techniques which were specifically designed to manage knowledge.

A structured approach was regarded as essential knowledge for software design. A broad range of skills and expertise were regarded as necessary to work in the industry.

Interviewees emphasised the importance of formal training. One interviewee in the Software and Computing Services sector described the most important feature of his knowledge, skills and expertise as, 'having a structured approach. I did a Software Design MSc at Salford University. They taught us to design functional blocks that work independently of each other. Then you can test each area of the application works independently. I'm a Microsoft Certified Solutions Designer. Microsoft teaches the same techniques – to break the requirements down into functional areas. Object orientated analysis and design enable you to reduce the number of iterations and get it right first time.'

Not unexpectedly, one-person organizations require multi-skilled individuals. Their knowledge is a mix of formal skills plus a range of cognitive skills based on mental ability and experience. An independent IT consultant described himself as having, 'intelligence, experience (that provides a base of knowledge), being intuitive with technical things, good at day-to-day information management (for example, setting up processes for stock control), financial management in small businesses, leading teams and risk averse.'

3. 3. Formal KM initiatives

As the use of formal KM tools or techniques is not widespread among the companies we interviewed, Section 2.3 describes in more detail the initiatives of one company, the multinational, to see what might be learnt from its experience.

There are a range of KM drivers, reflecting specific characteristics of the company, long-term market changes, and short-term business issues and the specific nature of the company activities that the company's work features.

KM within this company has been driven by a combination of factors. The sheer number of staff (c. 300,000 globally) is a striking feature of the company. The awareness that in all likelihood, somebody somewhere has already tackled the problem that another team is now facing has driven the firm to find ways to access the experience and knowledge that those employees have.

Long-term market trends have also played a part in driving change through the company. Management failed to tackle effectively the problem of falling sales of its core product. Meanwhile on more than one occasion, company employees have left to establish their own firms which have become so successful that they are now major competitors. These market changes have prompted the company to look at ways in which the new business ideas of staff can be given the opportunity to develop inside, rather than outside, the company.

Another driver is the changing business issues that the firm must deal with. For example, last year, the firm acquired a major competitor. This raised the issue of how to integrate the new employees into its existing business. Problems were not just cultural; the new staff had difficulty navigating the company's systems and knowing where to find useful information on the intranet.

Finally, some knowledge management issues are specific to the type of activities that the company undertakes. For example, the nature of the work means that many employees work off-site, spending long periods hosted by the client or simply travelling between clients. The difficulty is then how to 'harvest' the work from employees' laptops and how to encourage them to share with other employees, with whom they may have little or no contact. Another example reflects the project-based nature of the activities. Each project is won on the basis on a proposal – 'pre-sales work'. 70% of the proposals are the same; they all include a piece on the company, references and a description of methods. Yet many staff queries are about references, or what expertise the company has in a particular area. Here, the company has aimed to re-use knowledge to reduce the amount of time spent on proposals.

The company aims to share knowledge, integrate employees, re-use knowledge and add value to the business.

The company aims to encourage staff to share their knowledge and to access knowledge from across the world; it aims to re-use knowledge, as in the case of writing proposals, or finding employees who may have particular knowledge, skills or expertise, or have tackled a specific problem before; and it aims to add value to the business.

The company has implemented a range of tools and techniques to meet its KM aims.

The knowledge management strategy is based on people communicating, either face-to-face, or facilitated by IT. Groups try to meet face-to-face before meeting 'virtually' and plan to achieve face-to-face contact at reasonable intervals.

• Communities of Practice, such as that around Strategy & Change Community, involve consultants, at the core, who share knowledge and information with others with similar interests, on a voluntary basis. The Communities of Practice are surrounded by wider Communities of Interest, who take a less participative role, but nevertheless, keep themselves abreast of the Communities' activities. Communities use vehicles such as newsletters and sharenets to communicate, share knowledge and collaborate. • Communities may also form locally, based on local needs, typically with a stronger emphasis on face-face meetings. These are supported by the business. New groups are advertised and usually expand. A recent start-up has focused specifically on the application of emerging technology to customers' business problems.	• Direct knowledge sharing is enabled by allowing staff to take a residency of up to 3 month in the labs. This is 'formalised' through the creation of "red books" to share knowledge more broadly during their time there. • Mentoring and coaching, and pairing of senior technical professionals with younger staff, intentionally recreates a 'master-apprentice' model of knowledge sharing. • Story telling is used to provide a context for electronically-stored information. Stories and characters are also used in learning materials.

Table 3. Techniques to support face-to-face communication

The firm has developed a range of enabling technologies, to support knowledge sharing and collaboration, including:,

- Blue Pages – an internal directory of organizational information about individuals (role, contact details, reporting line…). Links to Persona.
- Persona – an expertise directory. Self-entered data. People are also able to post a digital photo and attach documents, including their CV if they wish.
- Global Knowledge Networks – These are global communities each with a global database /repository of intellectual capital. There are approx. 70 knowledge networks clustered around industry sectors, solutions or product areas, e.g. Strategy & Change, SAP etc. Each community is responsible for the intellectual capital in their area or expertise.
- Team rooms (Lotus notes) are used for sharing knowledge
- On-line forums
- Instant messaging
- Broadcast questions
- Intranet - – sophisticated portal and profiling. Customised content 'pushed' to user. Dependent upon the profile the user creates
- "Jams" – topic-led discussions that typically last 3-4 days. People post suggestions and comments and there may be votes. Each topic has a moderator.
- Dial-in meetings
- Web conferences (audio & video).

Table 4. Enabling technologies, developed to support knowledge sharing and collaboration

Incentives encourage staff to 'buy-in' to knowledge management initiatives. Some incentives are financial; others are 'prizes'. In many cases, participation is evaluated during staff appraisal.

The company in question valued patents very highly, so incentives to patent were correspondingly high. For example, $1500 was given to each member of a team that filed a patent, and a further $500 was given to each when the patent was granted. When an invention went on to give the company substantial commercial benefit, rewards ran up to $250,000.

Award schemes can also be useful sources of data. In one case, staff were rewarded for the best examples of the creation, and for the re-use, of intellectual capital through an open competition This generated numerous success stories demonstrating tangible business benefits through knowledge sharing.

The company put up an overall reward for knowledge-sharing of up to $5000 for individuals or teams. For other knowledge-contributions, or demonstrations of knowledge re-use, PalmPilots have been given as prizes.

The company has significant resources and is obviously equipped to give significant rewards. These reflect the value the company attached to knowledge management. However, it is interesting that giving PalmPilots became problematic because people could 'put a price on it.' After that, the company moved to giving 'red letter days' as rewards.

This reveals that although rewards may be a good incentive, and are a tangible demonstration of a company's priorities, it is not necessarily best to give an item with a specific monetary value. Small tokens of appreciation, especially those with novelty value, may be as effective as costly items.

Buy-in was also sought by management: 'You need sponsorship from leaders. Rather than talk to managers and say, 'This is important' and they agree, we write communications for them to send out. We're putting a KM slide together that they present at all their meetings.'

Cost-benefit evaluation uses quantitative and qualitative measures.

Assessing the costs and benefits associated with knowledge management initiatives is far from simple, as one interviewee acknowledged, 'This is always very difficult. There have to be demonstrable benefits to knowledge sharing to support investment in resources.'

When one knowledge-sharing initiative started, there was no knowledge sharing. So the company monitored who posted material on the database. This generated responses, but of questionable value: ('The problem is,' said one interviewee, 'garbage in, garbage out.') In the first year, they had a review in November. Before the review, they suddenly got a glut of contributions. Somehow a rumour had started that people believed, that they had to contribute two pieces of intellectual capital. After that, the company measured consistent contribution and started rewarding projects rather than individuals. There was no glut, a better quality of contribution and it enabled projects to have 'lessons learnt' sessions.

Knowledge re-use between projects is a key issue for firms in many sectors. In this case, the benefits were measured in time saved – staff were encouraged to identify things that can be re-used, and estimate how many days were saved. Additionally, a world-wide asset re-use database (with a web interface) was used as a repository of success stories. For example one success story involved a tool developed by help desk staff for automating call closure notifications to customers in different languages. This greatly reduced time spent by staff on closure notifications (the quantitative data being cost savings) and also ensures a standard high quality of reply (the qualitative data).

Certain items of value can be tracked through the financial system when reused. KM *systems* are also able to be monitored in terms of activity, usage, how many people contributing, and so on. People are asked to evaluate the impact and value of systems

Intellectual capital audit tools have not been not used to date, but Knowledge Network Healthchecks and Community Assessments are applied. Management's assessment of KM

involves a report of the best examples of KM on a monthly basis. So evaluation includes quantitative, qualitative and *anecdotal* data.

3. 4. Key lessons/findings

- The small firms that we interviewed in the Software & Computer services Sector used a wide variety of external sources to help them generate new ideas and solve problems.
- The sources that small firms drew upon were accessed, mostly, via the internet.
- The small firms in this sector had developed a structured way of capturing knowledge from within their business. This went far beyond the documentation of formal policies and procedures to include thoughts on potential 'bugs' in products, thoughts on inefficiencies within the firm and ideas for improvements and ideas for new business. These systems were not necessarily thought of as 'knowledge management systems' and were not necessarily terribly sophisticated.
- Software development demands a formal, structured approach, whilst operating a small business in the industry requires and a range of cognitive skills and experience.
- The aims of the formal KM initiatives of the large firm were closely tied to long-term market changes, short-term business issues and the specific nature of the core business activities.
- The multinational subsidiary that we interviewed in this sector had recognised Knowledge Management as an important means of utilising, and gaining value from, the assets held within the firm. Key lessons included the following:
- 'What works for some people doesn't work for others, therefore [the company] needs lots of different initiatives. There is also a time factor. Initiatives tend to work for about 6 months. The initiatives also require a lot of buy-in from the Communities [of Practice].
- 'Trying to formalize an informal network doesn't work. A technology like Sametime taps into existing networks. It enables people on-line to have a quick chat or ask a quick question. It can also be used to set up groups, so that comments or questions can be fired out to several relevant people.'
- The size of incentives and rewards were proportional to the benefit the company gained from the staff's development of the knowledge asset. But knowing the actual monetary value of a reward was not beneficial. Staff were happier with a reward of lower financial value (for example, a day in the Enclosure at Ascot) and

a greater 'wow' factor, than they were with something to which they could assign a figure in pounds (the PalmPilot).

- Sponsorship was seen as essential. The managers, who were expected to sponsor the KM initiatives, were supported by being given a slide that could be inserted into all the presentations they gave, helping them to reinforce the KM message.
- The large company assessed cost/benefit in a number of ways. Quantitative assessments included estimates of time-saved, as well as financial savings. Qualitative assessments included staff feedback, and even anecdotal evidence was presented to managers.

4. MANUFACTURING SECTOR

4. 1. Description of sector & research sample

The turnover of the UK Manufacturing sector, and the number of people employed in Manufacturing, are far in excess of those in Construction (National Statistics, 2000). Indeed, in 1999, both turnover and number of employees were around four times higher in Manufacturing. In contrast, in 1999, the total number of enterprises was slightly lower in Manufacturing, reflecting the relatively large size of manufacturing firms. Barriers to entry to Manufacturing include the cost of capital equipment. And competition from abroad, where there is a vast supply of low-waged labour, is high. In 1999, the balance of trade in Construction was £182 million.

Manufacturing turnover peaked in 2000 and then fell by 1.54% between 2000 and 2001. Gross Value Added at basic prices peaked in 1999 and has declined since then, falling by 2.4% between 2000 and 2001. In contrast, turnover in Construction rose by 7.9% between 2000 and 2001 and Gross Value Added at basic prices rose by 13.5% in this period. Both figures reflect an upward trend since 1995.

The term ‘manufacturing’ covers a wide range of activities. The Manufacturing firms interviewed for this report operated in different markets., except for two firms who manufacture equipment that could be classified within the Environmental Technologies sector. One develops and manufactures gasifiers, which combust waste to produce heat and gas. The gas can be burnt as fuel. The other is the arm of a German company that manufactures technically-advanced heating boilers. This company has diversified into the solar energy market, selling boilers powered by photovoltaic (PV) cells – a technology that is much better established in Germany than in the UK. The former employs 10; the latter 25 in the UK and over 7000 worldwide.

The two other firms operate in very mature markets in which the UK has traditionally been very competitive. One manufactures paints, floor mats and hand rails, targeting specialist markets such as Healthcare with products such as 'hygienic paint'. The other manufactures fine chemicals and undertakes speciality product contract manufacturing (in pharmaceuticals). Of these, the former employs 64 in the UK and over 2500 worldwide; the latter 400 in the UK and over 6000 worldwide.

4. 2. Informal knowledge processes

All Manufacturing firms tended to solve problems* internally. *Individuals did this alone, or by discussing the issue with colleagues within the firm. Sometimes there was consultation with people outside the firm, but this was infrequent and limited to suppliers.

In the smallest company, which develops and manufactures gasifiers, the Project Manager described how ideas are generated: 'In a design review meeting we sit down as a group and the team bat ideas about.' Team members would be the Project Manager, the design draftsman and the Technical Manager. An Electrical Consultant was a regular addition to the team. They invited others 'if necessary', such as a subcontractor in materials handling.

The CEO of the company in heating boilers said he would, 'Develop an opinion as to what the best solution is, then bounce my opinion off other people, like the Head of Domestic Sales, the Finance Director, the Sales Office Manager and the senior Salesmen.'

Similarly, the Head of Engineering at the contract manufacturer of pharmaceuticals said he generated ideas, 'In the bath, down the pub, by talking to people on-site or around the group, in the smoking shed or in corridors. If it's a specific local issue, we do brainstorming (but we suffer from a lack of discipline). If it's project-related, I ring a counterpart within [the company] or ring an engineering contractor.'

The other internal resources were limited to the intranet (for products from different companies within the group), product literature, manuals or drawings.

In contrast, there were many* general *(ie non problem-specific)* external *sources.

Example of general sources used by the pharmaceuticals manufacturer:

Good friends within the company & in competitors	Analysts' reports
Socialising in bar after conferences	Vendors ('One in particular seems to know more about [the company] than [the company] does')
'Body Shopping'	Trade free press
UCL	Scrip ('what's going on in pharmaceuticals land. They print rumours, but they're often accurate, so most companies buy it.')
Inter-firm alliance	
www.biofind.com (for rumours about the company, its competitors and clients)	
www.biospace.com (for news in brief)	

Table 5. Examples of general sources used by the pharmaceuticals manufacturer

The extensive sources of the contract manufacturer of pharmaceutical, noted above, might well be explained in terms of compensation for information, predominantly about firms in the industry, which might otherwise be gained by word-of-mouth. But the extensive networks of three of the other firms are better explained in terms of their attempts to break into new markets, or even shape, emerging ones. For example,

Examples of general sources used by gasifier manufacturer:

Gasnet: gasification network designed to bring the knowledge base together	Renewables North West
Prof A & Dr B (Aston University)	British Biogen
Contacts who have requested JVs (eg Newcastle, de Montford & Sheffield Universities)	Gasnet conference to socialize with others in sector
DTI Future Energy Solutions	Lunch/beer with engine suppliers, etc.
	12 magazines & journals per week

Table 6. Examples of general sources used by gasifier manufacturer

Examples of general sources used by paint and flooring manufacturer,

Government guidelines & law eg Disabilities Discrimination Act (product innovation to meet new requirements)	British Embassy (for market intelligence to enter Scandinavian markets)
Knowledge brokers (eg universities)	Renfrewshire Chamber of Commerce (for networking in new sectors eg hotels)
	Entrance Flooring Systems Association

Table 7. Examples of general sources used by paint and flooring manufacturer

Examples of general sources used by boiler manufacturer:

Product specialists	PV UK
Central Customer Advice Department (Germany)	Heat Pump Association
Solar Trade Association	CORGI
	Institute of Plumbing

Table 8. Examples of general sources used by boiler manufacturer

External knowledge sources for* problem-solving *tended to be limited to a few (around 3) per company.

Example of external sources for pharmaceuticals manufacturer:

'Institute of Chemical Engineers produce an essential publication called, 'PM for the Process Industries'	'International Society of Pharmaceutical Engineers produce baseline guides' 'Internet occasionally'

Table 9. Examples of external sources for pharmaceuticals manufacturer

Example of external sources for gasifier manufacturer:

Data, case studies and papers from previously published literature on gasifier design and filtration	Internet

Table 10. Examples of external sources for gasifier manufacturer

At the paint and floor mat manufacturer, the interviewee said, simply, 'I don't talk to many people externally'.

Limited consultation outside the firm over specific problems was attributed to a general knowledge-gap between the firm and others in the industry, the sheer depth of the company's knowledge of the technology they used, and, in one case, industry-level secrecy.

The companies we interviewed were very knowledge-intensive. Both formal (mode 1) and practical (mode 2) knowledge were very important. One of the manufacturers in the Environmental Technologies characterised their own knowledge as, 'Extensive engineering knowledge: mechanical engineering, chemical engineering knowledge. A detailed understanding of the process of gasification. A very good understanding of fundamental principles… We kept the cost and risk down by focusing on a particular problem and perfecting that particular process.' The boiler manufacturer described their knowledge as, 'Vast, precise and tested.' The depth of knowledge at the paint and flooring manufacturer was exemplified by a comment by the Production Manager, 'I don't have any problems. I have 15

guys working on the factory floor. One has been with me over 15 years, two over ten years, five over five years, five over four years and two over two years.'

The depth of knowledge that the firms had, both formal and practical, was far beyond many other firms. Therefore, when doing creative work, or problem-solving, the manufacturing firms that participated in this research were unlikely to consult external sources. Asked about external knowledge sources, the gasifier manufacturer said that they had not entered into any joint ventures because the universities' technology is far behind their own. Of their competitors, they said, 'We think the others are just not doing right.'

The boiler manufacturer had found that the heating consultants that designed systems which included their boilers relied on the firm to provide all the necessary information on PV, that Architects or Consultant Engineers (who are often relied upon by manufacturers to specify particular products) often completely misunderstood the capabilities of the product and, finally, that the boiler installers did not have the necessary skills to install the product.

In contrast, the pharmaceuticals manufacturer did not consult external sources to help solve problems because the pharmaceuticals industry as a whole is very secretive. One Project Manager said, 'I don't talk to people outside the organisation much. I'm worried about giving away sensitive information, so if I do, I talk in vague terms.'

Supply chain initiatives have been used to overcome the knowledge gap where it is seen as a problem.

The firm diversifying into new technology (PV-powered boilers) provide an interesting example of how a knowledge gap may be filled. Their approach was to work with various members of their supply chain to improve their knowledge of PV installations. They have established a 'Key Installer Programme' which aims to create a set of installers who, almost exclusively, buy and fit the company's boilers. This encourages repeat sales and has reduced the number of after-sales problems that the company must rectify. Lunch time presentations to consultants have provided them with more accurate information about the product, enabling them to have more realistic expectations. Additionally, in-house training has been put in place to improve staff's knowledge of PV.

Knowledge capture was generally limited within the manufacturing companies.

There is a heavy reliance on individual’s knowledge, much of which is not captured or codified. The CEO of the boiler manufacturer said, 'With the very, very rare exception, all of the information in terms of the detailed technical-side of our business is inside the heads of [names three people].' At the production site of the paint and floor mat manufacturer, the

interviewee said, "No, I don't document what I do. Given time they'd work out what I do.' At the sales office of this company, they acknowledged that there was, 'No company mechanism to capture knowledge that would make it accessible to others.' At the large manufacturer, conventional systems were relied upon, such as, 'Effective reporting, common drives, weekly meetings are minuted…' Only at the gasifier manufacturer were there explicit attempts to capture knowledge: 'There are reference files. Everything's logged. You could pick up why I do certain things. On a project, no one person knows everything. E-mails are forwarded – everyone sees literature and requests. [Do you tell others about new things you've done?] Yes. For example, with IT - If I find a better way of recording things, I let the key personnel know. If I find a good website, I let the others know.'

Manufacturing values both scientific and engineering knowledge and 'people' skills.

Formal, technical knowledge remains very important. The gasifier manufacturer cited, 'Extensive engineering knowledge: mechanical engineering; chemical engineering knowledge. A detailed understanding of the process of gasification. A very good understanding of fundamental principles. We're methodical, rigorous, have a hands-on approach. We've identified the areas we're weak in and sought advice and information. We kept the risk and cost down by focusing on a particular problem and perfecting that particular process (ie one bit at a time). We're goal-focused – objective and realistic. And we always have ideas for the 'next generation' of gasifier: the iron's in the fire. We don't try and produce the most advanced model we can. We produce something that we can guarantee will work well. And work on developing our ideas for the next model.' The interviewee also gave detailed descriptions of the scientific methods of measurement and observation that were used to solve problems during the development of each gasifier.

In the pharmaceutical manufacturer a mixture of science-based and organisation-based knowledge, skills and expertise were valued. One interviewee claimed, 'I have communication skills, I try to have a good relationship with people, I have project management capabilities, reasoning, problem-solving, I'm logical, my science background enables me to understand and better communicate with people in Development.' Similarly, her colleague listed his skills as, 'Organisation, planning, scheduling, knowledge of biopharmaceuticals and how to make them, financial management, communication and negotiation with other department heads.'

4. 3. Formal KM initiatives

Training, mentoring, work-shadowing and seminars are ways in which these manufacturing companies, and indeed many firms, have traditionally managed knowledge, although it is only recently that some companies have recognised these practices specifically as KM techniques. One such company is the large manufacturing firm that we interviewed. It recently began two initiatives from which lessons about Knowledge Management can be learnt; the introduction of a skills database and the implementation of a coaching system.

A skills database was developed to document staff skills and enable better project team formation.

The database was introduced when the company went through major restructuring, from being a matrix organisation to being a process-driven organisation. The database was created so that all the skills of the staff would be recorded, in a way that is 'searchable', so that teams could be created from staff with the right mix of skills.

Skills database: reasons for lack of success

- The data requested was too detailed, specific and far-reaching to be user-friendly for those either inputting or extracting data: The database was compiled in such a way that the information it requested was very detailed. It was difficult and time-consuming to fill in (one member of staff estimated it took half a day) and 'horrendous' to search. The Head of Engineering said that he had refused to force his staff to complete their 'profiles' on the database.

- The initiative had a sponsor, but the sponsor was regarded as ineffective: One interviewee said, 'We've got a champion for everything. The same 5 or 6 people are used. They're good at knocking down doors, steering projects. But often they have little or no understanding of what they're championing.'

- There was no incentive for staff to participate: When asked about how staff participation was being sought, the Project Manager replied, 'You get an e-mail saying, 'You haven't filled it in yet.'

- The coverage the initiative enjoyed was linked to its success (so far limited). When asked how much coverage the initiative had, the Head of Engineering said, 'They

can't demonstrate it's a good idea!' – implying the coverage had not extended beyond the site.

A coaching initiative was developed in response to the Human Resource issues.

The coaching initiative was intended to expand job roles (by 'multiskilling and upskilling' staff 'so jobs aren't passing from person to person') and address some morale issues (staff turnover has been high and has been attributed to the difficulties of career development within a 'flat' company and the company's location). Implementation had occurred on various sites, and had, apparently, demonstrated to some national differences towards coaching.

Coaching: reasons for lack of success.

- In implementation, the scheme had not met its original aims – it was intended to be 'expansive and inclusive'. But in practice, not everyone had a coach.
- The initiative had fallen short of expectations due to under-investment in training. No-one has been trained *how* to coach. This meant that, in effect, there was little distinction between coaching and managing.

Despite early problems, it was expected that the company would persist with the initiative. An interviewee said, 'It is half-arsed, but it will probably grow because the company is keen to pursue multi-skilling.'

4. 4. Key lessons/findings

- The sources drawn upon by manufacturing firms during creative work or problem-solving were usually *internal*. Moreover, individuals in this sector generally turned to colleagues, rather than other sources (eg documents).
- These firms had a very wide general (ie not problem-specific) network of *external* knowledge sources and contacts. This was most typical of companies who were in the process of developing new products or actively engaged in developing new markets.
- Some of the manufacturing firms were very knowledge-intensive and this created a knowledge-gap between themselves and others. The gap was bigger for the diversifying and the innovating firms. Whilst the knowledge gap was a source of competitive advantage for the innovating firm (gasifier manufacturer), for the

diversifying firm (PV boiler manufacturer), the knowledge gap needed to be filled. For them, this meant providing internal training within the company and education for the supply chain (boiler installers and building designers).

- Many of those interviewed within the Manufacturing firms had substantial amounts of formal science or engineering knowledge. This was complemented by business management and 'people' skills.
- The systems of manufacturing firms used to capture the activities of staff are very limited. In one case, project files were not kept. In another, prices were kept in a personal, rather than a shared file. Only in one case was there an *informal* attempt to capture new knowledge. An attempt at *formal* knowledge capture took the form of the skills database.
- Lessons learnt from formal KM initiatives such as a skills database or coaching suggest the need for
    a. a level of knowledge capture appropriate to the knowledge use;
    b. effective training;
    c. effective sponsorship or support (or perhaps some other means of engaging staff such as incentives or rewards);
    d. a user-friendly system (in this, one that is not excessively detailed, complicated or time-consuming)

5. AGRICULTURAL SECTOR

5. 1. Description of sector & research sample

The performance of Agriculture in terms of Gross Value Added (GVA) at constant prices (where 1995 = 100) shows its performance to be quite poor, but not far removed from that of Construction or Manufacturing. In the first and second quarters on 2000, GVA in Agriculture stood at 101.6 and 101.8. In Construction, these figures were 110.6 and 108.7; in Manufacturing, 102.8 and 103.2. (This is in comparison to Other Business Services, which reached 145.5 and 150.1 in the same period.)

The structure of the farming industry has some parallels with the Construction industry : a limited number of very large players, and a large number of small to medium enterprises, including many small subcontractors. Similarly, 'the majority of private engineering firms that are involved with construction services employ fewer than four people.' (Euromonitor; 2002). Farming (like construction) has lengthy supply chains, including machinery supplies, agrichemicals, feed and seed supplies. Of the companies we interviewed, one had 42 employees and a £7 million turnover (and owned several farms); one had 3 partners (the farmer, the farmer-ess and her mother) and 3 employees; one was run by the owner, his son and two employees; one was run by the owner and one part-time employee; one was run by one owner/farmer.

Whilst the construction project is often at the mercy of 'natural' influences, such as the weather and site conditions (affecting groundwork and access, for example), so Farmers' experience centres on programming work according to changing weather conditions. The weather has a severe impact upon the availability of fodder for cattle in both winter and summer (decisions include choice of crop grown, timing of harvest and whether to buy in feed), it impacts upon grazing management (the location of animals) and ultimately affects the cost, quantity and quality of milk yield in the very short term, meat produce in the medium term and, of course, crop yield over the season. These problems are exacerbated by factors such as the customer changing supply dates and are, arguably, more critical for those that have adopted organic farming.

Other problems include a wide spectrum from the breakdown of machinery, disease (short-term infections such as mastitis or the vaccination of herds), re-building sheds that have blown down and dealing with global competition and government regulation: 'working out what the regulations and policies mean and understanding the political and operational dimensions for the way forward.'

5. 2. Informal knowledge processes

Farming knowledge is built through a lifetime's experience.

The most striking difference between farming and any other sector is that all farmers had intimate knowledge of their trade based, literally, upon a lifetime of experience. Several interviewees were born on their farm. Their experience of animal husbandry had been built up from childhood. Many also had a formal further education (FE) in farming. But their tacit knowledge was very much a part of their identity.

The interviewees valued life-long experience of animals, as well as organisational skills. They identified their key knowledge as:

> 'knowing animals'
>
> 'being a good stockman (that is, I can relate meat on butcher's counter to living animals). This helps to increase profit margins. Organisational skills.'
>
> Expertise gathered since I was ten.

There is little distinction between problem-specific and general knowledge sources used in farming. However,* external *sources are very important. Farmers rely heavily on networks for discussion, advice and information about operational and strategic issues which they appear to tackle in tandem.

The Scottish farmers interviewed had the greatest variety in their networks of any of the sectors. Sources of knowledge and information ranged from the Royal Highland Show to farm visits. Furthermore, learning was an on-going, semi-structured activity. For example, one cereal farmer got regular advice from advisors and fellow farmers during monthly meetings held on different farms. An advisor presented the recent weather conditions, prevalent diseases, types of sprays he thinks should be used and their cost. A farm visit would follow, giving the opportunity to look at different crops on host farm. Then there were visits to other farms where there are particular problems. Discussion groups were common arenas of knowledge sharing. The Cereal group had been running for 17 years; a Potato group had been running for 4 or 5 years.

The knowledge sources of two of the farmers are described in Table 11.

Network of farmer Eg 1:	*Network of farmer Eg 2*
fellow farmers farm open days agricultural shows Scottish Natural Heritage Forestry Commission Farming and Wildlife Advisory Group Farm vet Scottish Agricultural College Scottish Quality Meat (formerly Meat & Livestock Commission)	Home Grown Cereals Authority (for market intelligence) EU (for future policies) Supply chain Industry networks Consultant 'friends' Scottish Executive (for policy documents) Trade press Commercial knowledge brokers Universities Newspaper (for political intelligence).
NFU (for political info on e.g. CAP reform) Southeast Environmental Rural Affairs Department Morden Institute (mainly for advice on domestic livestock diseases)	

Table 11. Knowledge source of farmers'

As in Manufacturing, when a company innovates, networks are used to learn from* external *parties.

Time pressure & low profit margins trigger innovative ideas which would improve productivity. Ideas are discussed with the Scottish Agricultural College, other farmers, and visiting company representatives (such as from feed manufacturers). These discussions help farmers to get a comprehensive perspective of current thinking. One interviewee described a change he wanted to implement. 'I'm currently considering introducing wood-chip corals for cattle bedding for winter. Corals help avoiding poaching of fields. Nobody has done it locally yet. I've asked the SAC to identify the nearest farm which is using these and estimate the cost. Once the information is gathered, I'll test it on a small site. I decided to pursue the idea after reading about it in a farming journal. The wet and cold weather might be a problem. The cattle might feel restricted on the corals & not respond well to it.'

Knowledge capture is not systematised, but regulation has increased the amount of formal documentation within farming businesses.

Since the BSE crisis in 1996, it has been obligatory for farmers to keep records of their produce. These usually take the form of diaries (known sometimes as 'cows records') and document the life history of all cattle and crops. They include daily events such as animals' medication and crop spraying. Moreover, these records extend up and down the supply chain to ensure complete traceability. In this way, the feed, for example, of any particular animal is traceable, sometimes around the world. The demand for records to be kept rigorously guarantees the quality of end produce.

Many farmers gather and record the information in electronic format. Some have 'expanded them to use for management purposes: I never kept anything before 1996, except a wee calving diary.' Others are now finding it necessary to keep more detailed records to meet other requirements, such as the information demanded by the organic inspectors.

Farmers operate in global markets: British farmers compete with those in countries whose regulations are not as tight. (Traceability is an example.) Global competition has forced profit margins down, putting farmers under great pressure. It also forces farmers to have a very broad perspective on their business.

One interviewee described the market conditions in which his business operated: 'When the Soviet Union was the Soviet Union, when Ukraine and Tajikistan were under the control of the Soviet Union, they produced very little grain. They were importers of grain. They were not exporters. Now, they are both separate countries. They are major producers and major exporters of grain. This has totally changed the balance of world trade in grain. Export from the Black Sea pushed the price of grain right down. We had to decide what we were going to do to counteract that. We decided we could not possibly compete with their price. So, we decided to have less grain, and more grass, and also to take advantage of the Government's "set-aside payment" which is about £200 per hectar. You would get this payment whether you produced grain or not.'

Of the interviewee's data collection practices, some of this involved tracking EU policies : 'The biggest source of information is obviously the market place, the reports, literature and what not that come out in the market place. We also get some material from the EU to see what their future policies might be.'

Farmers have very long-term perspective of the business. They look beyond the present yield to forecast future market opportunities, policy implications and so on.

Agriculture is amongst the most politically influenced of sectors. Events, and long-running political battles in Brussels have significant impacts on long and short term decisions by farmers. One interviewee said he was awaiting the EU's decisions on Common Agricultural Policy before the farm made short-to-medium term business decisions such as whether to employ more staff.

5. 3. Formal KM initiatives

There was no formal knowledge management amongst the companies that participated in this study in Agriculture.

5. 4. Key lessons/findings

- Farmers combine experiential knowledge, based in many cases on life-long learning, with formal further education.
- The absorptive capacity of farming sector seems to be very high. In addition to running their farms on a day-to-day basis, farmers are engaged in a wide variety of activities where they acquire new information, share experience and learn from one another (and probably generate new knowledge in the process).
- Farmers have had to respond to new regulation and establish or adopt new systems of information collection and documentation. However, their records do not extend to knowledge capture.
- Low profit margins are a driver of innovation. Companies draw upon external contacts and sources when innovating.
- Farmers operate in global markets. This creates tight profit margins. It also demands farmers have a broad perspective on their business, accounting for local, European and global factors. Farmers must also take a long-term, strategic perspective on business.

6. CONSTRUCTION SECTOR

6. 1. Description of sector & research sample

Construction is a large sector, employing over 1 million people and contributing around 10% of GDP. Gross Value Added (GVA) in constant prices has been increasing since 1995 and rose by 13.5% between 2000 and 2001. Turnover in Construction rose by 7.9% in this period. This improvement comes during a boom in the market, and a period of scrutiny and initiatives led by both Government and Industry. The industry is viewed by some as inefficient and slow to innovate. Such views may be supported by the overall GVA at constant prices, which, for Construction, stood at 108.7 in the second quarter of 2000. Corresponding figures for Business Services had reached 150.1.

The firms that we interviewed in this sector included a large Construction company with 7500 employees worldwide, a small civil engineering company in Scotland employing 95 people, a Construction company with 1000 employees, and a small roofing contractor with 40 staff (£3m turnover).

6. 2. Informal knowledge processes

Interviewees within the construction industry tended to engage with others within their firm, or within their supply chain, rather than those beyond. There is a heavy reliance upon experience in problem-solving.

An interviewee at a large construction company expressed, what would be termed, the importance of mode 2 knowledge: 'Construction is experience orientated. Experience gained through site work is necessary.' At another company, an interviewee described his own knowledge, skills and expertise as, 'Having come from the ranks, being a life-long learner and learning from others.'

Perhaps it is for this very reason that much of the tasks that employees described were heavily based upon communication. One interviewee described knowledge management within the firm: '90% of it is communication.' When describing his own creative work or problem-solving, he used similar terms, 'We discuss it with everyone associated with the contract… Innovative ideas emerge through informal communication.'

Often, issues are tackled by communicating with others, if not within the company, then up or down the supply chain. For the Estimator at a roofing contractor, this meant discussions with the Architect to establish client requirements or to get information on building regulations and their impact upon the roof design. The Contracts Manager at the same company described typical problems as, '1. Sourcing leaks into a building; 2. Resolving conflict within the

operations team and within the project team; 3. Poorly detailed design, specifically in D&B jobs.' Problem 2 was tackled by facilitating communication. The Managing Surveyor at a small contractor said much of his problem-solving involves communication with clients, subcontractors, his own Accounts department, internal Quantity Surveyors and internal Contract Managers. The work of a Design Manager at a large contractor revolved almost entirely around liaising between multiple parties, including the client, consultants, subcontractors, Commercial Manager and Package Manager.

An Associate at a large multidisciplinary engineering consultancy that has led the way in developing KM within the Construction industry said,

> You solve a lot of the problems by going back to the work you have previously done. Therefore, the knowledge you use is based on your life experiences. Some of this knowledge would be in your brain. Some of it would be on bits of paper. You refer to these. Or, you refer to your colleagues who you know solved that problem.

Use of external knowledge sources differs according to role type. Senior and/or 'commercial' staff use external sources particular to business development. 'Project' or 'technical' staff are involved in complex sense-making processes of knowledge generation, synthesis and acquisition through communication with supply chains partners.

One manager in a civil engineering company cited a number of external sources. Working under the title Chief Engineer, his responsibilities were in 'commercial' areas, such as business development, pre-qualification and bid management. He had no line management responsibilities for projects. Business development led him to utilise:

- Market intelligence from industry publications
- EU websites
- Word of mouth
- National press
- Networking
- Letters of commendation
- Trade & technical press
- Publications which track the planning process
- Personal network in industry
- Internet
- ICE's lending library

Table 12. Examples of sources utilised for business development in the construction sector

Similar sources were cited by an Area Manager working for a large national contractor whose work also involved business development.

Project staff have very different knowledge sources. Notably, these sources are predominantly people. The work of a Design Manager at a main contractor included, amongst other things, the following liaisons: presentations to the client at tender stage, attendance at workshops and reviews with the design team to convert the design from RIBA Stage D to Stages E and F, interviewing subcontractors then liasing with them mid- and post-tender, ensuring consultants sign-off contractor drawings, and value engineering with the design team and then the subcontractors. It appears that the external knowledge sources of project staff are other people within the (project-specific) supply chain.

When prompted to consider informal KM processes, Construction practitioners recognised that existing 'corporate' activities, such as training, had a KM function, though they were not regarded as KM initiatives.

When asked about informal knowledge management processes, staff located these processes within existing activities such as training, mentoring, de-briefing and the maintenance of conventional documents, such as a Standard Project Procedures Manual.

The Managing Director of a small roofing company emphasised the importance the company placed upon training. Skills training needs analysis had been done in collaboration with Scottish Enterprise and this had led to in-house training installation for labourers and out-sourced training in CAD. Some training was leading to the Scottish Vocational Qualification in Waterproofing; many staff had been trained in health and safety. The Construction Industry Training Board had profiled the company's IT needs and this had led to training in IT skills. Not all training was formal: the MD encouraged staff to learn from their mistakes and mentor others.

These comments were supported by other members of staff. One trainee said,

> If I was not sure about anything, I would speak to [the senior estimator]. He has been on the job much longer than me. [The senior estimator] makes my job ten times easier by passing on his knowledge to me. I came here straight out of college. I have been learning all my life. Learning continues here. I find it really easy to ask anyone. It is like a family here. I learn as I go along…I did a computer HNV qualification before I came here. I don't have a construction qualification. I had never known a structure, a roof. I had no idea how an upstand that I was pricing would look like in real life. When I started here, [the senior estimator] took me to the training shed at the back

> and showed me what was what. That helped me a lot… I have monthly meetings with the representative of a company that is responsible for my training to improve my skills - mainly communication. I discuss what I have learnt every month with her. These meetings count towards my qualification. It is quite good to explain what I have done to someone who does not know the company. It helps me to think about what I do and how it helps me to improve.

Construction interviewees recognised that, for example, training and mentoring involves informal knowledge management processes such as communicating or sharing knowledge, sense-making and perhaps other knowledge processes. However, as the next section attempts to illustrate, there was difficulty seeing where knowledge is captured within their companies.

Construction firms have particular difficulty with knowledge capture. Project knowledge is captured in project files. Knowledge on company process is captured on process manuals. There is little knowledge capture beyond this.

Since it is not unfeasible that knowledge is captured by individuals, or their colleagues, without a KM Knowledge Capture initiative being in place, interviewees were asked about informal knowledge capture. Some interviewees were forthright is stating that there was no capture.

> 'Project knowledge or experience is not captured, except procedural documentation.'
>
> 'Personal knowledge and experience is not captured.'
>
> 'Unfortunately, there is no system to capture knowledge. [The company] is fine now because a lot of the senior staff have served for a long time. If they left then [we] would have a problem: We need a system but it's not in place yet.'
>
> 'Tacit knowledge is not captured.'

In the firm specialising in civil engineering, information capture was formalised in facts and figures on past projects kept on a database, and on project de-briefing forms, designed to capture 'lessons learnt'. However, the interviewee described these as being, 'not accessible to new people because they'd not know where to look.' Another interviewee in the same company described how project de-briefing meetings had been introduced for Quality Audits to capture project knowledge. These meetings had lost their importance over time and representation at the meetings varied between departments and had generally declined. However, this employee, who had studied KM as part of an MBA, felt that these meetings were essential to knowledge sharing within the company.

A design manager of a large contractor which, as described in Section 6.3 below, had some strong KM initiatives in place (including Communities of Practice, a knowledge-sharing tool called *i*Konnect and a 'proposals library') described a number of documents as methods of knowledge capture. For example, the Standard Project Procedures Manual had just been up-dated. In another case, a Starter Pack had been uploaded onto the intranet, providing guidance for new staff. This included interface matrices, generic scope descriptions, checklists for reviewing drawings and a document submissions record for capturing change (ie designed to make consultants identify changes and explain why they have been made). She described this Starter Pack as, 'not a regimented way, a skeleton to be fleshed-out by individuals. If staff develop something good it can be added.' Finally, a Best Practice document had established 4 or 5 key areas, such as design programming and project close-out, and used people's experience to establish good ways of doing things.

As it was generally 'bald' facts and figures that were captured in project files or process documents, staff tended to be unaware of the experience and knowledge gained from any particular project unless this information was considered to be sufficiently ‘important’ to be disseminated through newsletters or a similar form.

Firms experienced some difficulties in sharing knowledge within their organisations.

The following quotes illustrate the difficulties some people experienced,

> 'The tendency to employ temporary labour impedes knowledge-sharing within Construction.'
>
> 'Reports in electronic format can be difficult to share with operatives.'
>
> 'We need to review the number of systems and procedures in place to focus on those that have tangible benefits, rather than following all the procedures in order to cover our backs in case there is litigation. We should increase social interaction between employees and keep morale high to improve communication.'

Some companies attempt to re-use information and knowledge from past projects to reduce the time and effort that goes into preparing new proposals, and to demonstrate to the client that they can deliver better value. At one company, this was a deliberate KM initiative; at another it was not.

In one company a member of Marketing Support is employed to design & maintain a 'Proposals Library'. The library is on CD & contains all the info required for pre-qualification documents, tender documents and expressions of interest. This information includes

company statistics, policy statements, insurance documents, the company accounts, documents on procurement, H&S, the environment, skills, sectors, regional capabilities, benchmarks, quality management, responses to questions such as what do you mean by Construction Management? How do you procure materials? Previously this information was collected repeatedly. Now the CD is distributed quarterly to 80 staff.

An interviewee at another company felt that the information put into pre-qualification documents reflected their in-depth understanding of the company and the way forwards. One member of staff produces a first draft of the document, covering 'technical issues such as resources, history, values'. Then, the interviewee and a colleague tackle the 'more difficult questions, which relate to company style, philosophy and attitude. Our responses are based on our knowledge of our company. We are both long-serving staff and we have a very good understanding of the company and the way forward'.

6. 3. Formal KM initiatives

The most interesting example of formal KM initiatives comes from one of Britain's largest construction companies. Whilst other companies, especially SMEs, might find it difficult to justify the dedicated resource that this company has invested, there are many lessons that can be learnt about effective KM initiatives. This company had several KM techniques, such as Communities of Practice, a Proposals Library and a knowledge-sharing mechanism. This latter initiative is described here.

The aim: The initiative is based on the proposition that the company is a knowledge-driven, service company. They do not make anything; all manual activities are subcontracted out. In effect, the only thing they sell is their knowledge. Because they don't make anything, they must demonstrate to clients that they add value in other ways, for example, that they're not repeating mistakes, that they innovate, that they achieve on time, cost and quality, and so on.

The objective: To be able to add value, the company wants to be able to access the knowledge that its employees have. They don't want to 're-invent the wheel'. If someone in the company has already solved a problem, or found a good way of doing something, then others should be able to take advantage of that. They need a means of sharing knowledge.

How it works: Knowledge-sharing is enabled by global facilitators that anyone within the company can contact (by e-mail or telephone) with a question, challenge, or opportunity The facilitators log all questions received so that they have a resource to search for future similar questions The facilitators' job is not just to log the question, but to understand the question, find and validate potential sharers and put the enquirer in touch with the shearer, who can be a member of staff or someone from the organisation's supply chain. Facilitators then follow-up each case by checking whether a successful connection was made and what insights may have been gained as a result of the connection.

The champion: In this case, the (then) CEO was not only the champion of the system - he initiated it. No business case was needed. He wanted a 'people' approach to KM, which was an innovative solution at a time when other KM initiatives were technology-based. He gathered a core team from the EU, US & Asia Pacific to develop the initiative, called '*i*konnect'.'

Implementation: The initiative was rolled out to senior managers first. Once the CEO was happy they were using it effectively, it was rolled out to everyone else and 1-2-1 briefings cascaded the initiative down the organisation. The knowledge management team (there are 3 in the EU, 3 in the US and 2 in Asia Pacific) have conducted visits to projects to explain

*i*Konnect and then returned later to demonstrate how it has been adding value. Information on the system is part of induction of new staff. The Directors briefed continental Europe before the initiative was implemented there.

Maintenance: The global *i*Konnect team have a conference call once a week for up-dates, communications planning, strategic discussion of the initiative (eg improvements) and next steps (eg. sell *i*Konnect).

***Performance measurement of the system*:** The facilitator follows up each question with a call to the enquirer for feedback. They evaluate, for example, the value of the insight (1 – 5 rating) and ask how the seeker has used the knowledge, to check they're applying the information. The seeker might elaborate more, providing good feedback, although the interviewees acknowledge that getting feedback might involve some 'chasing'. Feedback had also gone via company Directors from clients that have used the system. It is easy to track usage, and it can be segmented by region, for example UK North; UK South. The original target was one 'request for knowledge' per person. Now, the company measures 'best in class' – the biggest/heaviest user. There have been 6000 calls in 2 years.

***Performance measurement of KM personnel*:** The KM team had targets such as; to ensure *x* people had been briefed; to ensure *x* people had seen the CEO interview video; to grow the volume of RFKs by *x* amount.

Service appraisal: A bi-annual review evaluates what works well and what needs changing. At the last review, externals such as McKinsey Consulting had been brought in to share their KM experience. The EU team conducted interviews for the group to review. On another occasion, the Learning & Development Department organized a life coach to talk about listening skills. However, it was emphasised that the KM team was run in a 'hands on' style involving continual review.

Critical success factors: The interviewees were unanimous that communication was the key to success. The constant publicity included a new story on the intranet to demonstrate the value to business (how to win work, decrease costs, find a solution) every week. The interviewees also attributed success to the dedication of the senior management team.

Incentives: These were restricted to small objects that could be regarded as a token of appreciation, such as a flask with the *i*Konnect logo on, key rings and golf balls. These were given to knowledge seekers & sharers.

Barriers: Middle management had proved more difficult to get on board (those at the level of Project Director or Divisional Director). There seems to be a perception amongst some that

seeking knowledge is a weakness. Also, some people seem to feel comfortable in their 'silos': There is, amongst certain groups, a reluctance to look outside their team. Others were not totally convinced of the benefits of knowledge sharing – they don't see knowledge as a key differentiator.

Lessons learnt: The message was undoubtedly that IT-based systems don't work. A knowledge management initiative should be a simple process with a human interface.

6. 4. Key lessons/findings

- People rely heavily upon communication to solve day-to-day problems. For project staff, this is almost entirely within the company or the immediate supply chain.
- The industry values experience very highly and personal communication emerges as the most common, and maybe the most effective, way of transferring learning from experience.
- External sources are used to develop new business development and gather market intelligence.
- Most companies regard training as a means to improve on their existing knowledge.
- The industry, not surprisingly, finds it very difficult to capture knowledge gained from experience. These difficulties are exacerbated by a temporary, often nomadic workforce, divisions between site and office staff and a preoccupation with professional liability.
- A formal KM initiative (that the company judged successful) involved a high degree of backing from senior management and some dedicated resource. However, IT investment was low (indeed, for one case – web-enabling a 'proposals library' database - it had been decided that it could not be justified at the present time). Rather, dedicated staff were put in place to deliver and facilitate the initiatives, and appeared to contribute significantly to the initiatives' success.

7. SYNTHESIS & CONCLUSIONS

As discussed in the introduction, drawing 'best practice' lessons from one sector and attempting to transfer these to another sector is a non-trivial process. Each context is different, and lessons have to be understood and interpreted with this in mind. Differences may be highly significant, since they often focus on structural differences, and different basic assumptions and views.

Construction has been characterised, in recent decades, by the assumption that competitive tender is the most economic form of contractual arrangement. This has lead to a striking structural feature - bidding for packages on a project-by-project basis equates to short term supply relations between constractors and subcontractors. Recent challenges to this assumption – the assertion that better *value* can be offered by having preferred suppliers – have created some structural changes in the industry. That is, there are an increasing number of longer-term supply relations. Nevertheless, this is in contrast to the assumptions and structural features of Agriculture, where, among the firms that participated in this study, the assumption is that farmers will deal with the suppliers that their parents and grandparents dealt with. And supply relations are very long-term. The difficulty of drawing 'best practice' lessons is exacerbated when further complexities are considered. For example, the structure of the Agricultural sector involved in supplying to supermarkets is likely to be very different than the sector involved in supplying local-speciality or organic products to restaurants.

It is striking that the construction sector interviewees used internal knowledge sources and supply chain partners as knowledge sources for problem-solving, whereas the responses of the agriculture sector interviewees reflect a world view that doesn't necessarily distinguish short-term problem-solving from general knowledge acquisition or long-term strategic problem-solving. The horizon and pace of the problem agenda is qualitatively different. If the first lesson is to raise awareness of these multi-faceted differences in context, perhaps the second is that construction could learn from farming and place longer-term horizons on the problem agenda.

Table 13 helps present the national view of the industries that have been involved in this research. In terms of value-added, Software and Computing Services is a top performer. However, Construction makes a major contribution to the economy as, like Manufacturing, it employs vast numbers of people (in the case of Construction, 1.4 million). Furthermore, it contributes around 10 % of GDP.

There is no reason to think that the Software and Computing Services companies that we interviewed are not typical of companies in their industry. However, some of the companies that participated in this research were probably atypical of their industry. For example, although Manufacturing is stagnant in Britain in 2003, two of the firms that participated in this

research are in the 'sunrise' sector of Environmental Technologies. This means that they are in a new, potentially lucrative, line of business and, in fact, the manufacturer of gasifiers is at the forefront of innovation and a British market-leader. Indeed, it is possibly the sole commercial manufacturer in its market segment in the country. Another of our manufacturing firms operates at the innovative end of what is a well-established and profitable market, contract manufacturing (biopharmaceuticals).

The Construction firms that were interviewed did not represent the vast majority of microbusinesses that operate in the market, but probably were typical of SMEs and large companies in this industry. Similarly, the farmers that we interviewed operated microbusinesses, which is typical of hill farmers, but not of large arable farms.

What does this mean? In the first instance, although there appear to be some commonalities between firms within a particular sector, as previous sections of the report have indicated, it is not possible to conclude that these similarities or themes are typical of the sector as a whole. Furthermore, whilst it might be useful to consider broadly, whether it is desirable for Construction to learn from one industry rather than another, greater attention should be paid to the *experiences* of the individual firms that participated in the research.

Sector	**Agriculture**	**Software & computer services***	**Manufacturing**	**Construction**	**Architectural and engineering**
Number of Enterprises 1999. Source: ABI	**3,263** **		**170,196**	**188,304**	
Total turnover (£ million) 1999. Source: ABI	**698** **	**36,385*****	**461,771**	**111,365**	**23,200*****
Gross Value Added at Constant 1995 prices for year 2000 (Q2). Source: National Statistics	**101.8**		**103.2**	**108.7**	
Total employment average during the year 1999 (thousand). Source: ABI	**8** **		**4,269**	**1,313**	
Employee Jobs Great Britain (unadjusted) in 1999 (thousands). Source: National Statistics (2000)	**294**	**440**	**3,936**	**1,064**	**304**
Balance of international trade 1999 (£ million) Source: National Statistics		**1,428 ('Computer & information')**		**182**	

Table 13. The national view of the industries that have been involved in this research

* Comprises Software consultancy & supply, Maintenance & repair of office, accounting & computing machinery, Hardware Consultancy, Data Processing, Database Activities & Other Computer Related Activities. Standard Industrial Classification (1992) Divisions 72.1, 72.2, 72.3, 72.4, 72.5, 72.6.

** Annual Business Inquiry, Figures for 2000, released 18/06/2003.

*** This figure for 1999. The UK Service Sector, 2000. London: Office for National Statistics.

**** Standard Industrial Classification (1992) Division 74.2

Cross-sector comparisons: Table 14 provides cross-sectoral comparisons of the sectors, summarising some of the main themes that emerge.

		Software & Computing Services	***Manufacturing***	***Farming***	***Construction***
K Sources (Problems)	Internal		x		x
	External	x		x	x
K Sources (General)	Internal				
	External	x	x	x	
Essential knowledge		Structured style of software development	Combination scientific knowledge, organisational & interpersonal skills	Knowledge of animals and organisational skills	Construction experience

Table 14. Cross sectoral comparisons

7. 1. Synthesis of findings

At the beginning of the report, 7 knowledge processes are identified:

- creating / generating / producing knowledge
- communicating, sharing knowledge
- searching / sourcing knowledge
- synthesising / transforming / combining knowledge
- capturing / codifying / storing / classifying knowledge
- mapping knowledge or knowledge proxies
- applying and re-using knowledge

The report has identified many of these knowledge processes within the firms that participated in the study. This is summarised below.

Creating: This research provides insight into knowledge creation by looking at occasions where problems are solved or where creative work goes on. Very different patterns of behaviour have been revealed. The internet is an important tool for people working in Software and Computing Services (SCS), providing them with access to a wide range of technical information from multiple sources, such as enthusiasts, practitioners and manufacturers. Information ranges from casual comment, to discussions, to formal white papers. SCS practitioners also browse book shops and reverse engineering competitors' products. In fact, they engage with a wide variety of sources, many of which are outside the firm, when they embark upon knowledge creation.

In contrast, Manufacturers solve problems alone or with colleagues. Practitioners are likely to turn the problem over by themselves and approach immediate colleagues, either formally (in

a meeting) or informally (say, in the smoking shed). They utilise relatively few sources of codified knowledge; this tends to be limited to product literature, manuals and drawings.

In Agriculture, knowledge creation seems to be more closely integrated with other knowledge management processes such as general knowledge acquisition and knowledge sharing. Problem-solving or innovation involves some discussion with co-workers and family members, with other farmers and with visiting company representatives (eg feed manufacturers). One farmer in this study requested the Scottish Agriculture College do some research on his behalf.

In Construction, knowledge creation is a process that happens either within the firm or between supply chain members. In the case of 'commercial' staff, such as Estimators, Quantity Surveyors or Commercial Managers, problem-solving is likely to go on in consultation with colleagues, but may utilise various sources of information from inside or outside the company (such as in the case of business development, or in looking at market prices). In contrast, 'project' staff, for example, Designers, Design Managers, Construction Managers and Package Managers, are likely to consult many people outside the firm – but only those related to the project upon which they are currently working. Moreover, they are unlikely to consult other sources of knowledge or information, with the exception, perhaps, of product specifications. This indicates that Construction professionals, and project staff in particular, do not consult as widely as practitioners in SCS, Manufacturing or Agriculture when creating new knowledge and perhaps are not exposed to as many sources of new information.

None of the firms interviewed had KM initiatives to support knowledge creation.

Communicating & Sharing: SCS professionals engage in a lot of communication and sharing, much of which occurs via the internet. Internet-based chat rooms, discussion groups and bulletin boards are among the less formal forum for professionals to share their knowledge with others. The internet also operates as a platform for 'gurus' to 'show off'; this too involves a form of sharing. Manufacturers share some of their code – the building blocks of software – so that professionals can fix, adapt and develop their products. And an entire computer language, Linux, has been developed collaboratively within the public domain. The large CSC firm that participated in this research has numerous technologies to facilitate sharing between its members of staff and has also promoted Communities of Practice – voluntary membership groups organised around sharing and learning.

Manufacturing practitioners are less amenable to sharing their knowledge outside the organisation[1]. In addition to concern over losing their competitive edge, there is reluctance to

[1] The fear of losing competitive advantage is much stronger here, perhaps because there is a greater possibility of their losing a sale when the customer is choosing between products off

share with people who are unable to reciprocate with a similar 'quality' of information. Nevertheless, the interviewees were part of networking organisations (eg Gasnet), trade associations (eg Solar Trade Association) and had informal and formal links to universities. Interestingly, although not seen as a KM initiative, there was a deliberate attempt to close a knowledge gap by training supply chain members (eg training plumbers on PV installation). One manufacturing firm had developed a formal KM initiative around mentoring, a traditional form of knowledge sharing within the firm.

In Agriculture, farmers also have deliberately developed forums specifically designed to share knowledge. Groups have been organised for farmers with common interests (Cereal and Potato Groups) and farm visits are held, utilising a highly experiential form of learning.

In contrast, it is difficult to see where Construction shares knowledge between firms outside of commercial agreements and the purchase of services. Although there is some movement within the industry towards integrated supply chains and, in that, the possibility of shared problem-solving and a more collaborative form of working, this does not imply communication and knowledge sharing of the kind which SCS or farming practitioners engage in. In fact, not only does there appear to be no knowledge sharing beyond the purchase of services, but even *within* commercial agreements, collaboration is incentivised through joint gain/pain share arrangements. None of the participating construction firms indicated any knowledge sharing outside the firm. One had done a great deal to facilitate sharing *within* the firm, with the development of a knowledge-sharing tool, as described in Section 5.3. It had also promoted Communities of Practice and supported staff with the provision of time, resources and publicity. Another firm had encouraged mentoring, though less formally. Construction seems to fall some way behind other industries in the informal communication and sharing of knowledge.

Searching & Sourcing: The CSC sector uses the internet to search widely for different sources of knowledge and information. Other avenues for sourcing include membership of organisations that are 'gateways' to knowledge (eg Trafford Park Business Forum) and formal and informal contact with the local universities.

Similarly in Manufacturing, the participating companies are members of organisations (eg Envirolink Northwest) that are established specifically as a conduit to other firms, to sources of funding and a guide to public organisations. They are also in personal contact with the DTI as well as utilising the resources that the DTI provide publicly (DTI Future Energy Solutions; British Biogen). In addition, they have strong links to the universities (eg contacts that advise

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the shelf than the possibility of a CSC professional losing a client that has made a major investment decision in an IT solution that is tailored to the client's own particular requirements.

on process and design; doctorates that they supervise). Manufacturing firms also subscribe to a number of scientific/engineering journals (eg Bioengineering), subscribe to electronic news up-dates and visit websites to find the latest information (eg. www.biospace.com).

In Agriculture, the Scottish Agricultural College has an interesting role as an information provider, responding to requests for information from individual farmers (eg. the coral).

In Construction, interviewees involved in business development listed sources such as the trade and technical press and the national press. And a large multidisciplinary engineering consultancy and a major contractor both had libraries, though interviewees from these companies admitted to, in one case, not having used the library at all for a long time, and in the other, it simply not being a primary source of information. The picture that emerges from Construction is one where staff, particularly project staff (both on- and off-site), do not source beyond the project team.

Synthesising/combining: Knowledge synthesis involves, for example, combining a Psychologist's understanding of the workings of the brain with a Manager's understanding of the work environment to create new knowledge – Work Psychology. In application, this might be mean a new pay or incentive structures. This study did not find evidence of knowledge synthesis.

However, at least one company worked within an environment where combination occurred – the manufacture of biopharmaceuticals is based upon knowledge of biotechnology and chemical engineering. And the Design Manager in the construction firm that we interviewed interfaced between many different design disciplines (architecture, structural and M&E engineering) as well as with construction contractors and commercial staff although, this is usually regarded as an exercise in co-ordination, rather than combination.

Nevertheless, it may be that a different research methodology is required to be able to detect, or better, understand, where knowledge combination takes place.

Capture: Only the SCS firms that we interviewed employ a structured approach to capturing knowledge from within their business. Interestingly, this includes even the smallest 'one man band'. Some of the systems for capture are sophisticated and are integrated with other business information systems. Others, like that of the IT consultant working alone, were simply MS Word documents that captured thoughts and ideas, filed in such a way as to be easily retrievable. Typically, the CSC professionals captured thoughts on potential 'bugs' in products (or anticipated future problems), inefficiencies within the firm, ideas for improvements to the products and the business and noted business development opportunities.

In terms of formal KM initiatives, one manufacturing firm had developed a database designed to capture and map the knowledge and skills of all its members of staff, although this had not

been entirely successful. With this exception, manufacturing firms did not capture knowledge, and had varied levels of sophistication in recording standard *business* information.

Farmers did not attempt to capture knowledge; indeed, it was not until recently that farmers started to keep any records of any kind.

Construction and manufacturing firms are similar in that they both have varied levels of sophistication in capturing business information. For example, in one case, prices were kept on personal rather than common drives. Capability to capture and retrieve business information, which is a codified form of knowledge, may reflect upon capability to capture knowledge, which is not codified at all. (The implication being, if a firm is unable to capture 'tangible' things such as facts and figures, where will it begin to capture 'intangible' things such as expertise?) If this is the case, it suggests that many construction firms still have some way to go. However, it should not be assumed that capture will take place with the same tools and techniques as business information.

This study found that many interviewees in Construction felt that their firms were failing to capture tacit knowledge or experience. This is interesting, because in other sectors, attempting to capture *experience* did not appear to be on the agenda at all. Two firms kept a database. One database stored facts and figures on past projects, and project de-briefings, designed to capture 'lessons learnt'. However, these were described as 'not accessible to new people because they'd not know where to look.' Furthermore, another interviewee commented that the de-briefing meetings had lost their importance. The database at the other firm was known as a 'Proposals Library'. This kept up-to-date information that is commonly needed to be included in tender documents. It was maintained by one dedicated member of staff and disseminated on CD. In essence, it was the centralisation of data storage and up-keep particular to proposals and tenders. This had proven more successful.

Overall, then, whilst there were some concerted efforts to capture knowledge on the part of construction companies, the most comprehensive initiatives were those of SCS companies. These appeared to involve everyone within the organisations and tended to involve more timely and context-dependent knowledge, such as capturing thoughts on potential 'bugs', as opposed to more 'concrete' knowledge about, say, human resource policies, which are relevant for longer pieces of time, and make sense in more than one context.

Mapping: When asked how they know *where* to go for information, all the interviewees replied that it was from experience, or secondarily, by asking someone else. The research indicates that the human brain has well developed schema for mapping knowledge. Mapping is something we do automatically to organise our knowledge. The concept of knowledge mapping is more usefully employed in relation to formal knowledge management. For example, the manufacturing company that attempted to document staff knowledge and skills in a database did so by relating the knowledge and skills to the name of the person who had

that knowledge. It is not helpful to know that particular knowledge exists in your organisation without knowing where to find it. As Section 3.3 describes, creating a database of the knowledge and skills of staff was not an easy initiative to pursue.

Applying: It is difficult to identify when knowledge is being applied. Certainly this is an important process – many companies seek competitive advantage from the application of new knowledge or the application of old knowledge to new situations. At one extreme, *everything* people do involves the application of knowledge, even trivial, mundane tasks such as using a telephone. Usually, when people are being more discrete, they look to identify innovation within the firm. Of the firms that participated within this study, one could argue that the manufacturing firms were by far the most innovative, creating (gasifiers, biopharmaceuticals) or introducing (PV boilers) new technologies. This is debatable, but a discussion of measures of innovation is far beyond the scope of this report.

Formal knowledge management: Success factors

There was broad agreement amongst the people interviewed regarding the characteristics of the best KM tools and techniques and what made the initiative a success. They are listed here,

Simplicity: The initiatives were simple. Where an organisation (such as the large IT company) was trying to achieve different KM objectives, several smaller initiatives existed, rather than one 'all-singing, all dancing' one.

Human interface: Users interface with a person, not an IT system. Of the initiatives described which featured databases, those where users interfaced with someone who interrogated the database on their behalf were successful, whilst the initiatives where users had to interface directly with the database were not.

Evaluation: the initiatives are assessed regularly and evaluations include quantitative and qualitative data. In many cases, this includes anecdotal evidence. The performance evaluation of the knowledge management staff, and in some cases the general staff, is related to the usage of the KM tool or technique.

Champion: The effectiveness of the champion is related to the success of the initiative. It was deemed essential to have a genuine champion for the initiative. In addition, managers were supported by being given material, such as presentation slides, which helped them promote the initiative during the course of their daily work. However, champions need to be well informed and understand their brief.

Internal marketing: Marketing was used to communicate to staff, not only the existence and function on the initiative, but to promote the initiative and its *benefit for staff*. Internal marketing involved highlighting the initiative's plus points, such as how it could help the

individual work more quickly, find answers more easily or produce better solutions. Telling the initiative's success stories was also crucial. Internal marketing was a continual exercise.

Rewards: Incentives or rewards were given for knowledge sharing and re-use. These varied considerably in value from large cash rewards (for patents in an IT firm) to key fobs (in a construction company). Both initiatives were successful. Rewards are useful for demonstrating the strength of the company's commitment to knowledge management, but a small token of gratitude can be as effective as large 'prizes' and neither are a substitute for a genuinely useful initiative with a person, not an IT, interface and strong management support.

7. 2. Recommendations: Lessons for Construction

The following checklist is based on the findings presented in this report. It provides a diagnostic tool that organizations may use to assess their own knowledge processes and initiatives against these findings. It is not assumed, however, that all the factors are relevant to all contexts - there may be good reasons why they don't apply.

Please tick the box which best describes the extent to which the following constructs applies to you & your organisation.

Constructs	Strongly agree	Agree	Don't know	Disagree	Strongly disagree
There is a recognition within your organization that it is knowledge-based					
You are making use of external knowledge and information sources					
Your organisation is making use of external knowledge and information sources					
Your organisation have the internal capacity and capability to access and absorb external knowledge and information					
You are aware of the knowledge drivers affecting your business (e.g. knowledge about markets, technology, competitors, regulation and legal framework, etc)					
You would benefit from taking a longer-term perspective on your business (While there are some 'quick wins', many knowledge initiatives may require extended time-frames to reap benefits.)					
Your organization shares knowledge effectively					

Constructs	Strongly agree	Agree	Don't know	Disagree	Strongly disagree
You have an organisational culture that encourages communication and knowledge sharing (this is likely to be dependent on duration of employment, and staff perceptions of job security and trust, as well as reciprocity).					
Training is highly valued in your organization					
Staff are equipped with the generic skills to learn independently, as well as highly targeted and specific training					
Your organization re-uses knowledge					
Your organisation frequently re-invents the wheel					
You could encourage more sharing and re-use, such as introducing after-action reviews or lessons-learned sessions, or forums where questions can be posted and contacts made					
You are aware of communities of practice within your organization					
Communities of practice within your organisation can be better supported (bearing in mind they may function best as informal communities)					
Awareness of specialist knowledge of the communities of practice can be communicated more widely (even if the knowledge itself cannot)					
Experience is key to knowledge acquisition. Your organization benefits from retaining staff as they grow through experience					
People in your organisation move on, taking their expertise, gained in your organization, with them					

Constructs	Strongly agree	Agree	Don't know	Disagree	Strongly disagree
Staff circulate into different areas of the organization (e.g. secondments), or work in cross-functional teams, in order to share knowledge					
There is a system of mentoring for new staff in your organisation One approach is to pair senior and junior staff (analogous to the apprenticeship system).					
Your organization is aware of the value of story-telling					
You use technology to support people-to-people communication (e.g. expertise directories, on-line or web forums, etc).					
You get staff buy-in to knowledge management initiatives. Options to improve buy-in include financial or other reward incentives, including prizes, or formalised agreement in annual appraisals.					
You have identified knowledge champions					
Knowledge champions have adequate knowledge and understanding of the business areas they seek to influence					
Knowledge champions are supported by high quality information and training					
You have top management commitment to knowledge initiatives					
You have middle management commitment to knowledge initiatives					
There are there structural issues that need addressing					
You are aware that knowledge processes happen informally, and that attempts to over formalise and manage these may not always work.					

Constructs	Strongly agree	Agree	Don't know	Disagree	Strongly disagree
You have identified where and how you already manage knowledge					
You could improve on this					
You apply cost-benefit analysis to knowledge management initiatives For example, you may record time and cost reductions through knowledge sharing and re-use. Generating appropriate criteria – e.g. timescales and performance measures – requires awareness of knowledge issues					

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