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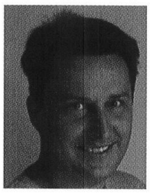

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Abstract The results of a research project dealing with knowledge management in project environments and the capability to transfer knowledge across projects teams are presented. A key distinction is made between generic project knowledge (kernel knowledge) and specific project knowledge (ephemeral knowledge). For each type of knowledge, knowledge management benchmarks are described and discussed. The empirical data used in this paper was collected from companies of various sizes operating in the manufacturing, construction and service sectors.

Keywords Project management, Knowledge management, Types of organization

Introduction

Despite the popularity of knowledge management as a source of competitive advantage, the knowledge management literature has been criticized for its lack of empirical basis and for a strong emphasis on the conversion of tacit knowledge into an explicit form through the use of information technology (Pan and Scarbrough, 1999). In contrast with this technology-driven view of the management of organizational knowledge, some authors have suggested that the novel contribution of knowledge management has been to reveal the importance of collaboration at all levels of collective forms of work (von Krogh and Roos, 1996). This is why, "in its simplest form, knowledge management is about encouraging people to share knowledge and ideas to create value-adding products and services" (Chase, 1997).

One of the prime areas to which this knowledge management approach could be applied is the field of project management. All business sectors are adopting a project approach to carry out a range of vital operational or innovative activities, and the leverage of project-based activities on overall company performance keeps intensifying. However, project knowledge management is generally accepted as sub-optimal, both within companies and along the supply chain. Knowledge is generated within one project and then lost. Failure to transfer this knowledge within the organization or along the complexities of the supply chain leads to wasted activity (i.e. "re-inventing the wheel") and impaired project performance. In recent years, there has been a heightened focus on project knowledge management in IT and in management literature. Main contributions are discussed in the literature review.

Literature review

In the management oriented literature, a number of academics and practitioners have expressed an interest in the relationship between knowledge management and project

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> In its simplest form, knowledge management is about encouraging people to share knowledge and ideas to create value-adding products and services.

management (Kamara *et al.*, 2000; Gilbert and Holder, 2000). However these original contributions provide only limited, anecdotal guidance available for practitioners wanting to improve their capability to manage knowledge in project environments. Braiden and Hicks (2000) presents a review of knowledge management activities in the engineered to order capital goods industry (an industry very dependent on the use of projects) from a process-based perspective. Orange *et al.* (1999) introduce the COLA review process as an example of a system able to trigger reflection and the formulation of lessons learned in the construction industry. According to the designers of COLA, what lacks in the construction industry is reflective practice. Finally, Disterer (2002) provides a comprehensive discussion of the knowledge management problems faced by IT project organizations operating within routine organizations, and provides three key recommendations: post-project review processes, project profiles associated with "know-who" databases, and "project experience managers".

In the IT literature, there has been a strong focus on modeling the concept of "project memory". The focus is either on the use of object-oriented technology (Weiser and Morrison, 2000) or on the construction of relevant data structures (Matta *et al.*, 2000). Leseure and Brookes (2002) provide a detailed review of IT systems which are useful for knowledge management activities in a variety of project contexts.

Thus, previous publications on project knowledge management have remained anecdotal or specialized as they have focused on specific academic disciplines (process, IT) and/or specific business configurations.

Benchmarking is an ideal tool to attempt to generalize the observations of good practices to larger sets of data. The benefits that benchmarking can provide in terms of pragmatic directions for knowledge management have been established by Chase (1997) and O'Dell *et al.* (1999). The goal of this paper is to apply a qualitative benchmarking approach to identify current knowledge management practices in project contexts in a broad variety of industries.

Data Collection

The data was collected through semi-structured interviews focusing on knowledge management problems and practices. Table I displays some general information about the interviews.

The selection of the interviewed companies was not random. As the research project originated in the engineering sector, some sectors are highly represented: aerospace, R&D, construction, and capital goods. Other sectors were added on (utilities and services) in order to provide a more diverse database from which general findings could be extrapolated.

However, as interview results started to be gathered, the authors realized that the capability to generalize findings would not be achieved by covering several sectors but rather by observing different types of projects. This is consistent with the findings of Shenhar (2001), who has for some time researched the idea of classifying projects. His view is that differences between projects can only be explained in terms of contingency domains (Shenhar, 2001). For example, company 4 and 5, although belonging to the same sector, were interviewed about totally different types of projects (product design vs. strategic sourcing project). The inclusion criteria used by the authors aimed to achieve observations for very different types of project, whilst maintaining enough commonality to draw comparisons.

An important distinction introduced at the data collection stage was that between companies with a "one-off" project strategy versus these with a focused innovation strategy.

In the most general cases, companies operated in "one-off" projects, i.e. there was few or no economic learning curves derived from repeat project performance. For instance, in

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Table I Data sources

Industry	Interviewees	Size of organizational unit being discussed	Project strategy	Projects discussed
1. Aerospace	Project manager	More than 1,000	One-off	Product design
2. Aerospace	Business development manager	Less than 100	Focused innovation	Product design, business improvement
3. Aerospace	Program manager	Less than 100	Focused innovation	Product design
4. Aerospace	Engineering manager	Less than 100	Focused innovation	Product design
5. Aerospace	Program manager	Between 100 and 500	One-off	Strategic sourcing
6. Utilities	Project manager	More than 1,000	One-off	IT projects, service design projects
7. Capital goods	Vice president	More than 1,000	Both	Various – technical and business improvement
8. Utilities	Director	More than 1,000	Both	Various – technical and business improvement
9. Capital goods	Director Chief engineer	Less than 100	One-off	Machine design and manufacture
10. Capital goods	Director	Less than 100	Focused innovation	Machine design and manufacture
11. Construction	Division director Foreman Project manager Construction planner Estimator	Between 100 and 500	One-off	Construction projects
12. Service	Division director	More than 1,000	One-off	Consulting
13. R&D, engineering	Division director	More than 1,000	One-off	R&D
14. R&D, engineering	Project manager	More than 1,000	One-off	R&D, IT projects

the manufacturing industry, a company may simultaneously have one project dealing with the design and building of a customized milling machine and another project dealing with the design and building of a cheese unmolding machine.

Other companies defined a key generic product, and would restrict their production to a well-defined target market. For instance, a manufacturing company may specialize in the design and manufacture of cheese packaging machines. Each product is based on a slowly evolving concept design, and operations are managed as projects mainly to customize each product to precise customer specifications. These companies use a focused innovation strategy. In these companies there is at all times the superposition of project organizations operating within the backcloth of a routine-oriented organization.

Knowledge management challenges in project environments

A majority of interviewees linked their knowledge management problems to discrete events in the evolution of their company's organizational environment. Significant events included:

- downsizing and other large re-organization initiatives;
- termination of a long-term relationship with a supplier;
- departure of an entire project team, high turnover, or gaps in the age distribution of a unit; and
- significant company growth.

The smaller organizational units that were interviewed confirmed whole-heartedly the notion that in small project organizations, knowledge management is embedded in traditional work practices and human values. Significant changes in organizational environments, such as growth, disturb a homeostatic knowledge management equilibrium, and create the need for more explicit and formal initiatives in terms of managing knowledge. However, the interviewees who saw in knowledge management a program for restoring or sustaining good practices were concerned that the adoption of a technology-driven, formal program may lead to a ''bureaucracy of knowledge''. In other words, they were concerned by the risk of ''over-managing'' the situation and ultimately being counter-productive. The emerging pattern from the research interviews was that the two key challenges of managing knowledge in a project

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environment are: (1) the collective accretion of knowledge; and (2) the management of tacit forms of knowledge.

Collective accretion of knowledge

One of the key challenges faced when managing knowledge across projects is the construction of a collective knowledge base. Interviewees highlighted the following key problems:

- incentives to contribute;
- knowledge ownership; and
- life-cycle knowledge management.

Incentives to contribute: in the research interviews, interviewees often highlighted that there is little incentives for individuals based in projects to contribute to the development of a collective knowledge base across projects. They complained that not enough time was spent on post-project reviews and on formulating lessons learnt from these. The time spent contributing to the formulation of organizational knowledge may adversely affect the perception of performance of a project currently undertaken: for instance, the time spent to write a "lessons learnt" memo can be considered to be unproductive from the standpoint of the project where it has been formulated.

The drivers to contribute are generally linked to professional culture, personal virtue, the desire to appear pro-active, personal recognition motives, etc. No evidence emerged from the companies surveyed of explicit approaches in place to propagate these drivers.

Knowledge ownership: the construction of a knowledge base necessitates mechanisms to attach knowledge ownership to individuals and/or groups. During the research interviews, the answers of project managers indicated difficulties in achieving this. Where ownership structures and rights were known and explicit, interviewees indicated that transfers of knowledge were usually feasible. Conversely, failures to transfer knowledge were often linked to an ambiguity regarding who owns a particular type of knowledge.

Life-cycle management of knowledge: Siemieniuch and Sinclair (1999) have stressed that knowledge, like many other productive assets, has a life-cycle. A new form of knowledge is created; it is refined through different business applications until it reaches a usefulness peak, after which its usage decreases until it is replaced by a more novel form of knowledge. During the research interviews, it became apparent that the collective construction of knowledge was essentially a conservative process. Innovation and the formulation of new knowledge always appeared as a challenge to existing knowledge beliefs. Thus, a key challenge when building a collective knowledge base is to reach a strategic balance between stability and innovation.

Managing tacit knowledge

The second key challenge facing the companies surveyed was the management of tacit knowledge. This type of knowledge is the personal, embedded, nebulous form of knowledge that is nevertheless essential for effective operations. A majority of the companies surveyed highlighted the key role of knowledge experts in the creation and diffusion of tacit knowledge. These experts, or "gurus", were very experienced individuals who were often the unique repository of critical forms of knowledge within a project team or within the whole organization.

Although experts can be used very effectively to manage tacit knowledge, their existence also generates challenges in terms of knowledge management. Experts are "gate-keepers" and it is largely at their discretion to whom they disseminate knowledge. In many of the companies surveyed, experts saw their role as spreading and propagating knowledge as widely as possible. However, knowledge experts can also act as a constraint on knowledge transfer processes, as a "gatekeeper" can become a "bottleneck". The retirement of a knowledge expert can create a threatening challenge if the transmission of the expert's knowledge is not addressed in due time. In some situations, it was also noted that the presence of experts led to "knowledge laziness" in the rest of the population. If an expert is always on hand to provide knowledge, individuals see no reason to acquire that knowledge for themselves.

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Knowledge management benchmarks

In order to present with clarity the findings from the research interviews, this paper uses a typological model of best practices. A first dimension of this model deals with the different grades of project knowledge. This distinction is derived from the empirical observations made during the research interviews. The second dimension of this model deals with the structuring of knowledge management systems and is borrowed from the knowledge management literature.

Grades of knowledge

During the research interviews, it became clear that interviewees were dealing with different grades of organizational knowledge.

On one hand, some interviewees focused on a form of knowledge akin to the core competencies of a company. This type of knowledge, labeled kernel knowledge, includes forms of knowledge that need to remain and be nurtured within a company in order to sustain high project performance in the long-term. Because kernel knowledge is what allows project teams to repeatedly complete independent projects in the long term, it matches the accounting definition of an intangible asset, i.e. an economic resource from which future economic benefits will be derived. Kernel knowledge is a form of generic project knowledge.

On the other hand, the completion of a project also requires access to project-specific knowledge, that is knowledge which is useful for one project but has a low probability of ever being used again. This form of knowledge is labeled ephemeral knowledge, as it is only active and useful during the lifetime of a project. Ephemeral knowledge does not match the definition of an intangible asset as there is no evidence or guarantee that it will be useful again in the future.

Precise examples of kernel and ephemeral knowledge can only be formulated with caution, as the grading of knowledge is intimately linked to a company's project strategy. For instance, in the capital goods industry, knowledge of machine design is always a form of kernel knowledge. Knowledge about the process of wrapping cheese is a form of kernel knowledge for a company with a focused innovation program on cheese packaging machines. The same knowledge is ephemeral for a machine manufacturer dealing with one-off projects in a variety of industries.

A final distinction between kernel and ephemeral knowledge is that project teams not only use kernel knowledge, but they are constantly improving it or creating new forms of it. On the other hand, ephemeral knowledge is rarely created or modified by project teams. Ephemeral knowledge is usually generated externally to project teams, for instance by regulatory bodies, suppliers, and customers.

Knowledge management systems

There are a large number of models of knowledge management systems that could have been used to structure the findings of this survey. At the early stage of the project, a decision was made that technical aspects should not dominate the research, and that efforts should be made to research the relationships between technical and human issues. The school of socio-technical systems theory is the ideal theoretical background for such a program. However, socio-technical systems theory has been developed in the social sciences and applied primarily to the field of work design. The only information management application of socio-technical systems theory is the work of two French IT researchers (Bressand and Distler, 1995) which was used by Pan and Scarbrough (1999, 1998) to describe the knowledge management system developed and used by Buckman Laboratories. This model structures knowledge management systems in three layers:

(1) **Infrastructure**: the hardware/software which enables the physical/communicational contact between network members.

(2) **Infostructure**: the formal rules which govern the exchange between the actors on the network providing a set of cognitive resources (metaphors, common language) whereby people make sense of events on the network.

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(3) **Infoculture**: the stock of background knowledge which actors take for granted and which is embedded in the social relations surrounding work group processes. This cultural knowledge defines constraints on knowledge and information sharing.

These three layers were useful to categorize the practices of the surveyed companies, provided that a prior distinction between kernel and ephemeral knowledge was used.

Knowledge benchmarks

Table II displays the best practices identified during the research interviews. These best practices are described in more details in the following sections. The presentation of the benchmarks is based both on the interviews and the literature review.

Management of kernel knowledge

Kernel knowledge is a project-generic form of knowledge that is applied to all the projects that a company deals with. Thus, a key issue is to insure the consistency of the application of kernel knowledge, that is, to avoid the emergence of parochial team cultures and work philosophies. To this end, a key goal of the management of kernel knowledge is the ability to transfer it within projects (i.e. from the project montage team to the execution team, if different) and across projects (i.e. to avoid re-inventing the wheel).

Infrastructure

Top executives can modify an existing infrastructure or create a new infrastructure in order to support and facilitate the natural flows of kernel knowledge that take place in organizations. From the research interviews, patterns of practices could be observed. A pre-condition of managing this infrastructure is to have gained a strategic awareness of kernel knowledge. From this stage, a number of actions can be taken. In this paper, these actions have been classified into generic infrastructures, specific technical infrastructures, and specific organizational infrastructures.

Strategic awareness of kernel knowledge. At the operational level, project and program managers were always able to name and describe what they thought were key high-grade knowledge "pockets". However, the degree of difficulty of eliciting the identification of kernel knowledge varied between companies. The companies that exhibited high project performance

Table II Best knowledge management practices in project organization

	Kernel knowledge	*Ephemeral knowledge*
Infrastructure	■ Level 1 – Strategic awareness: nature, owners and users ■ Level 2 – Generic infrastructures: office libraries, corporate universities, "experience project managers" ■ Level 3 – Specific technical infrastructures: dedicated software/expert systems ■ Level 4 – Specific organizational structures: dedicated organizational structures: virtual organizations and back offices, job redesign (knowledge-based role definition)	■ Membership in interest groups, associations, etc. ■ Corporate libraries ■ Relationship networks and/or competencies databases (ERP) ■ Knowledge sharing intranets ■ Consulting and outsourcing
Infostructure	■ Elements: formats, templates, procedures, stage gates and other process models ■ Strategic balance between spontaneity and control	■ Groupware systems ■ Procedures and stage gate models
Infoculture	■ Horizontal collaboration culture ■ Transmission of legacy: training, mentoring ■ Recruiting and selection ■ Involvement in the social construction of knowledge: roadmapping, statement of intent, memos, newsletter, workshops, etc ■ Learning mechanisms: post-project reviews, post-mortem phases, after-action reviews	■ Contribute to receive culture (not knowledge engineering) ■ "Keeping current culture": newsletters, workshops, and training ■ Collaboration in the supply chain

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and who managed to transfer some knowledge across projects had usually identified these knowledge pockets internally. In their cases, the knowledge of the high-grade pockets seemed to be common, i.e. widespread throughout the company. The companies that did not seem to perform so well took more time and reflection before finalizing a list of high-grade knowledge pockets. In these cases, the interview seemed to capture a personal rather than common viewpoint on kernel knowledge.

Although the number and the nature of the knowledge pockets varied greatly from one interviewed company to another, there were common re-occurring themes, as shown in Table III.

The strategic awareness of kernel knowledge goes beyond a simple categorization of key forms of knowledge within the company. For each "category", top performing companies were able to explain key properties and relationships:

- who were the different owners and users of each knowledge type?;
- the existence of complementary relationships between experts (e.g. full knowledge is only activated if two or more individuals collaborate); and
- the existence of conflicts of interest either between owners, or between owners and users.

Generic infrastructures. The most natural type of infrastructure used to facilitate the management of kernel knowledge is the "office library". In its most informal form, an office library is a loosely managed collection of heterogeneous documents. For instance, in design offices, interviewees frequently referred to their "bibles", documents listing design rules and the results of key experiments done previously in the company. In its most elaborate form, an office library can include scanning/electronic archiving systems with search and retrieval capabilities.

The concept of corporate universities (e.g. Matthews, 1998) is a more advanced generic infrastructure. Different colleges can be created to address each pocket of kernel knowledge, and the key owners of each type of knowledge become the professors.

Finally, Disterer (2002) mentions in his discussion of IT departments the creation of "experience project managers" or "catalysts" who are specialized project knowledge librarians, or "intermediaries". In the surveyed companies, there were no employees with such a profile, with the exception of one organization which had appointed a "project knowledge manager".

Specific technical infrastructures. Whereas the infrastructures described above can be applied generically to manage any type of kernel knowledge, in some cases, companies develop specific dedicated infrastructures for a type of knowledge. For instance, product introduction teams often use customized, internally developed software/expert systems to

Table III Typical high grade knowledge pockets in project environments

Typical knowledge pockets	*Description*
Proprietary product/process technology	A form of knowledge that has been developed in-house by several generations of employees, e.g. a manufacturing process, a design methodology, or a set of design rules. Usually the most "sacred" of all knowledge pockets
Craftsman's know-how	A hands-on, general knowledge of the practices of the trade in which the company operates. Owners, engineers and managers initially trained as apprentices are the most critical of the lack of this type of practical knowledge in project teams
Specialist technician's skills	A highly specialized form of knowledge, usually possessed by technicians rather than engineers/managers. It develops as a result of accumulated experience in a specialist domain, i.e. reliability engineering, assessment of technical risk, etc.
General business skills	General business skills such as notions of project management, cost modeling and familiarity with an industry

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handle a key design decision, e.g. a proprietary sizing technology. On one hand, the use of such a dedicated software system could be interpreted in terms of the economic benefits of a faster design process resulting from the automation of design steps. On the other hand, from a knowledge management perspective, these software systems exhibit numerous additional functions:

- they are the official collective knowledge repository;
- any modification or evolution of the system (and thus of the underlying knowledge) is automatically documented; and
- ownership rights are explicit (i.e. not everybody can modify the source code).

Specific organizational infrastructures. Some of the interviewed companies had modified their organizational structure to provide a more effective organizational layout for the management of kernel knowledge.

During the research interviews, two key benchmarks were observed: the creation of virtual organizations; and job redesign initiatives.

Some companies had created virtual teams of experts around a type of kernel knowledge. For instance, a large company can have pricing engineers doing the same jobs and facing the same daily problems in different offices, sites and countries. As individuals, they only use their personal experiences of past projects to estimate the price of future projects. They all use spreadsheet models that they have developed independently to facilitate/automate their jobs. As they are isolated individuals, they have limited means to have an impact of the management of pricing knowledge at the company's level. If instead all these individuals are part of a virtual team, they can cross-fertilize their ideas about improving the pricing of projects. They can also be supported by a specific budget and by back-offices including secretarial, IT and business development staff. These knowledge-based virtual organizations are an effective way to improve the organizational support provided to project teams (Johns, 1999).

The second benchmark in terms of organizational infrastructure was knowledge-based job redesign. Some of the interviewed companies indicated an interest in redesigning the roles of the project's actors to eliminate unnecessary knowledge transfer problems. Attempts to do so were anecdotal (e.g. project managers were made responsible for concept design and pricing), and thus it was impossible to derive generic guidelines from the research interviews. The lack of versatility of project actors (e.g. weak financial and administrative background) was identified as a major hurdle to redefining project roles.

However, from a theoretical standpoint, these experiments in job redesign could be analyzed in the light of a school of job design, action theory, formulated by German job design researchers (Parker and Wall, 1998). In action theory, work is defined as being action oriented, i.e. as being a collection of elementary activities. There are two important features of actions:

(1) an action encompasses a number of activities – defining a goal for the action, translating it into plans, executing these plans, and finally, receiving feedback from the action; and

(2) any action is subject to an individual cognitive regulation – some actions become highly routinized (e.g. an assembly line workers' task) whilst some can never follow a rigid, identical structure (e.g. a commercial engineer's sales tactic).

One of the golden rules of action theory is that the responsibility for the completion of an action should be allocated explicitly and exclusively to one individual, and never to a value chain made up of distinct individuals (i.e. no vertical division of labor).

Some of the interviewees confirmed that projects were more effective if the integrity of the decisions made throughout the project was maintained. For instance, knowledge transfer problems occur when the concept design and the detailed design phases of a project are done independently. The exchange of detailed specifications can reduce the occurrence of these problems, but personal contact between the two parties is a more effective way of insuring a

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smooth transfer of knowledge. Finally, if the same person handles the two jobs, there are no problems of knowledge transfer whatsoever.

Infostructure

All the interviewed companies exhibited typical elements of an infostructure: the use of standard formats, templates, procedures, and stage gates models of the formal communication system of the company. Developed to an extreme, an exhaustive infostructure indicates who will send what information to another party in a specific context.

However, an extensively detailed infostructure was not identified as a best practice. In fact, the heavy emphasis on a detailed infostructure was a poor practice, and produced cases where confusion between procedures and kernel knowledge was observed. Some interviewees insisted that all the key knowledge of their company was the set of procedures and operating rules.

The companies that exhibited high project performance and that were successful at transferring knowledge across projects were characterized by their ability to reach a strategic balance between spontaneity and control of their information flows:

- Their infostructure was not so bureaucratic and prescriptive that it would encumber the spontaneous flow of information between two parties. For instance, a project manager could easily submit an improvement idea to a director without writing a formal memo and use an official channel.
- Their infostructure was extensive and formal enough to prevent a "communication jungle". For instance, a standardization of formats can avoid a failed communication attempt because a Microsoft user has problems converting a document sent by a Lotus user. In order to prevent an information overflow and wasting time, stage gate models can be used to provide guidance (rather than prescribe) to potential contributors in terms of self-analyzing the relevance and format of their messages.

Infoculture

A number of interviewees stressed limitations of explicit forms of knowledge. In one case, explicit knowledge was described as being messy: it would take several hours to locate a piece of information in a collection of ring binders. Moreover, even if this explicit element of knowledge was located, its users may still feel unsure about applying it. If instead an expert was consulted, it could take only a couple of minutes to exchange the information needed along with guidance and reinsurance that this was the right thing to do. An interviewee described this as a process of "holding hands". In other words, evidence was collected that many companies do not rely on formal procedures, process models and IT systems to manage knowledge, but on social interaction. This section describes the best practices observed in companies that managed their infoculture.

Transmission of legacy. Some of the interviewed companies expressed a key concern for the transmission of knowledge between the different generations of employees. They did not expect new recruits to have any proficiency in their kernel knowledge. Instead, they expected a normal proficiency in basic background skills. For instance, an aerospace manufacturer would expect its new recruits in its design department to have a good understanding of structural analysis. The efforts the best companies made to transmit their legacy of kernel knowledge often went beyond a simple training program or the request to read an internal report. Some companies had introduced a formal mentoring program and were assigning new recruits to mentors in the project teams. New recruits were also being rotated between projects and mentors in order to be trained in all types of kernel knowledge. A certification process was used to validate the end of the apprenticeship. In the interviewed companies using this methodology, the importance of socialization in order to transmit personal and embodied forms of knowledge was stressed.

Recruiting, selection and work atmosphere. A majority of the companies exhibiting high project performance were extremely concerned with recruiting and selection. In short, they wanted to hire the "right people", who would integrate the existing teams and work cultures.

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Technical skills were presented as a secondary element in terms of the selection criteria. To some extent the recruiting decision was seen as the preventive aspect of managing a company's infoculture.

A number of interviewees also expressed their will to manage a nice, flexible and friendly work atmosphere. This was presented as a way to: (1) maintain a background that facilitates collaboration through socialization in the workplace; and (2) retain employees within the company.

Involvement in the social construction of knowledge. Companies have a variety of ways to communicate the strategic ideas of headquarters to their project teams. Such communications are a unidirectional way of building a work culture based on shared values. Typical tools used in the interviewed companies to express the ideas and beliefs of top management were the use of roadmapping tools, memos, newsletters and leaflets, and informal workshops.

Learning mechanisms. Companies can take a step further in terms of their involvement in the social construction of knowledge. The use of learning mechanisms, where top management, project management, and project team members can express their perceptions of the problems encountered during a project is a multi-directional process of building a work culture based on shared values. Examples of such learning mechanisms in the interviewed companies were post-project reviews, post-mortem involvement and after-action review (for the review of a problem during a project).

Disterer (2002) insists in his recommendations for best project knowledge management on the adoption of post-projects reviews. However, his perspective seems to be process-based – that is the main outcome of these meetings is knowledge content archived for reuse. From the research interviews, where companies could be categorized in a clear-cut dichotomy (post projects reviews are useful or useless), the conclusion was different. The companies that benefited from post-project reviews indicated that the major benefits are not archived reports: instead it is the culture of information sharing that is being built, the training in discussing controversial issues, in reaching consensus, and the knowledge of each team member opinions, which generate true value.

Management of ephemeral knowledge

One of the interviewed companies mentioned the case of a project which was initially evaluated as a very successful project. A project manager had negotiated a 25 percent bonus for the promise of the on-time delivery of a customized food-processing machine. The deadline was extremely short and there was no record of on-time delivery in the last five years in the company. Nevertheless, the machine was delivered on the due date. The management of the company often used the practices implemented by the project manager as a benchmark of excellent project management. When analyzed in more detail in the context of this paper, this case study exhibits an excellent management of kernel knowledge. For instance, the project manager often consulted experts not belonging to the project team when an assembly problem occurred. These experts gladly collaborated and provided rules for superior design that the original designer never elicited.

However, the customer returned the machine three weeks after the delivery as it did not comply to a number of regulations of the food processing industry (e.g. welds, safety around cutting tools). For many individuals in the company, this controversial project became another example of poor project management. However, a more detailed analysis shows that the failure in this project came from a failure to manage ephemeral knowledge. The project manager had been warned that the machine may not pass industry regulations on a number of occasions, but

> **“Failure to transfer knowledge within the organization leads to wasted activity and impaired project performance.”**

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these informal warnings never included precise, factual information about the regulations, simply because these regulations were not linked to the core competencies of the company. The project was characterized by a number of contractual documents including a mention that food processing industry regulations should be followed, without anybody being able to state clearly what these regulations were.

This example shows that kernel and ephemeral knowledge are equally important in terms of managing projects effectively. However, due to their different natures, their management in project environments require different tools and mechanisms.

Infrastructure

Ephemeral knowledge infrastructures are the sources that project teams can use to acquire the knowledge that they need for a specific project.

The involvement of a company in interest groups and associations has been a traditional source of ephemeral knowledge. The use of consultants or research laboratories is the costly version of the acquisition of ephemeral knowledge through third parties.

Corporate libraries can also be a source of information regarding regulations in different industries and current technological trends. However, the limitation of corporate libraries is that on-demand access capabilities are expensive. Usually, the retrieval of a document may take some time, and the document may not be up to date.

In the small companies that were interviewed, interviewees stressed the importance of the internal knowledge of the distribution of competencies within their companies. For a specific problem, they knew who to contact because they remembered that an individual had to deal with a similar problem in the past. The consistency with which the importance of know-who knowledge was mentioned during the research interviews suggests that the key to the management of an ephemeral knowledge infrastructure rests in the management of these databases of competencies. The knowledge management literature confirms the current increase of the popularity of these competency databases in larger companies, which use either ERP systems or dedicated software (Tansley and Newell, 2000; Wallstrom and Lindgren, 2000).

The key difference with kernel knowledge is that with ephemeral knowledge, managing knowledge content is uneconomical. It is more effective to record only the source of knowledge, or a link to the source of knowledge.

Finally, knowledge intranets provide an ideal, real-time infrastructure to access who knows what in a company. Knowledge intranets can be used as elaborate ''know-who'' databases. The extent to which knowledge intranets can also be used to provide some knowledge content is more controversial. If what is being sought is an operating procedure, a mere technical fact, i.e. any form of knowledge which is easily carried by an explicit medium, then knowledge intranet can be used to provide knowledge content. However, if what is being sought is insight, experience, or how to handle an ''exception'', then it is likely that a knowledge intranet is better used by simply providing a link to an expert.

Infostructure

In terms of infostructure, the use of groupware systems was quoted by two interviewees as a key improvement of the capability to distribute and discuss ephemeral knowledge in large projects teams. To the difference of kernel knowledge with its long-term process of reuse and incremental updates, ephemeral knowledge is used on a short-term basis and discretely. Thus, issues of timing are usually critical, and the various functions embedded in groupware systems (real time diffusion, management of access rights, automatic diffusion to groups of users, etc.) provide the infostructure necessary for a live exchange of ideas when it is necessary.

Procedures and stage gates models that provide guidance in terms of checking compliance to regulations and compliance to the work program are also useful in terms of structuring the information exchanges dealing with ephemeral knowledge.

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Infoculture

In large organizations, IT systems play an important role in terms of enabling the management of ephemeral knowledge. Some interviewees pointed out that too often, a pre-conception existed in the workforce that the joint association of IT and knowledge management meant the implementation of a knowledge engineering system. In such a case, the workforce could resist the implementation of a knowledge intranet or could refrain from submitting accurate competency records, as they felt the knowledge intranet competed with their individual roles in the company. One of the interviewee had successfully implemented a knowledge intranet and insisted that a pre-condition was to create a culture of "contributing to receive" to avoid unnecessary resistance at the implementation stage. The goal of a knowledge-sharing intranet system should not be to replace or short-cut the need for knowledge experts, but to facilitate the identification of these experts and to provide effective ways to initiate contact with them.

Another aspect of the infoculture is to maintain a "keeping current" work culture where project team members are encouraged to keep current about technologies and the evolution of their industries. Newsletters, workshops and training tools can be used to reinforce such a culture.

Finally, suppliers in the supply chain are often a key source of ephemeral knowledge (in most cases, the ephemeral knowledge for a project team can be the kernel knowledge of a supplier). In this case, there is a need to extend the notion of a collaborative culture to relationships with the suppliers.

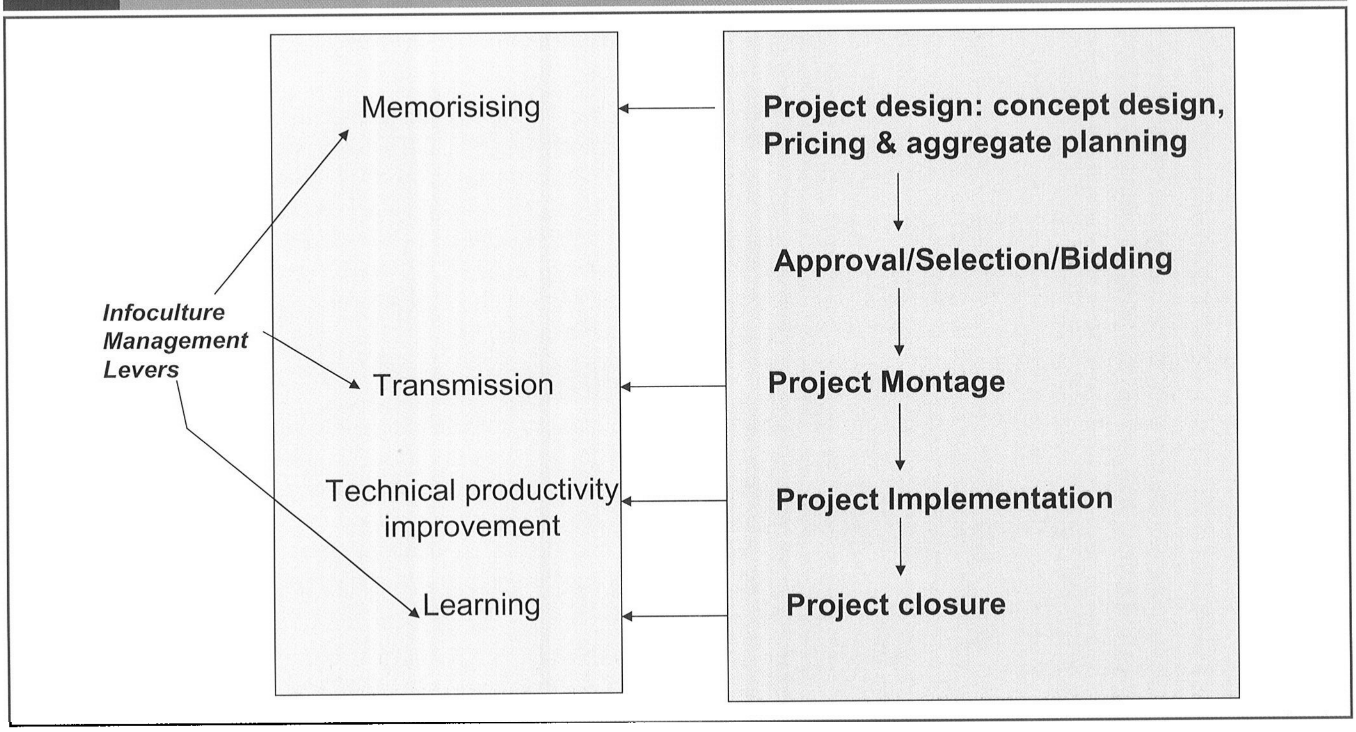
Implications for managers

The purpose of this section is to summarize the findings from the standpoint of managers concerned with improving the effectiveness of project teams through knowledge management.

Figure 1 illustrates that managers should consider the adoption of best practices depending on the stages of the project at which poor performance is perceived as more crucial.

Projects start with a project design phase: the objectives, constraints, specifications of the project are defined by a team of individuals who will not necessarily belong to the project team.

Figure 1 Implications for management



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> “Project management and knowledge management can only go hand in hand.”

Time and financial resources are scarce at this stage. The key challenge for managers is to memorize in details the decisions that are made and why they are made. Managers can improve this stage through the adoption of best practices in infra- and infostructures. The right infoculture is also critical at that stage as past knowledge should be used to generate the best project design.

If the project is funded, the next phase is to launch the project by selecting the team members, preparing a detailed plan and budget, etc. At this stage, the key knowledge challenge is the transmission of all relevant knowledge to the newly appointed project team. Infoculture is a critical component here as:

- it is unlikely that any technical system, no matter how elaborate it is, could ever guarantee an effective transmission of all knowledge; and
- it is necessary that a culture to contribute and help exists, whether or not the transmission of knowledge to the project team is supported by a technical system.

At the implementation stage, management cannot improve effectiveness anymore through infoculture. If individuals do not collaborate at this stage, it is unlikely to be a reversible pattern. The adoption of best practices in infra- and infostructures are useful at this stage only to provide productivity improvements.

Once the project is completed, the key challenge is learning, that is to capture all the lessons learnt in this project so that they can be re-used by other teams. At this stage, best practices in infoculture are crucial to guarantee effectiveness.

Figure 1 isolates infoculture management levers to stress that the right infostructure is a pre-condition for any manager who wants to improve project performance through knowledge management. Technical best practices (infra- and info-structure) will not solve human or organizational problems. Technical best practices are used effectively when the objective is: to automate or improve the productivity of existing practices; or to apply existing best practices at a larger scale than would be possible solely through inter-personal relationships.

Conclusion

In this survey of knowledge management practices in project environments, a key finding was the differentiation between kernel and ephemeral knowledge. In a repetitive manufacturing environment, all the knowledge that needs to be managed would be kernel knowledge. The existence of ephemeral knowledge complicates the task of project management, as the methods, tools and mechanisms used to manage them are not necessarily the same. For instance, there is a risk of information overload if one wants to manage ephemeral knowledge as kernel knowledge.

In the early stages of the research, the hypothesis that project management and knowledge management could be conflicting paradigms was formulated. This hypothesis is explicitly supported by the project knowledge management literature (e.g. Disterer, 2002). The focus on short-term performance and the organizational isolation of the project concept could be interpreted as conflicting with the long-term knowledge management goals of the organization in which the projects are organized. However, it became clear during the research interviews that there was a strong correlation between good project management practices and the evidence that project teams exhibited good practices for managing knowledge. Conversely, the companies that stated that knowledge reuse across projects was a key problem also stated that they had problems implementing good project management practices. For instance, they would organize post-project reviews, but key members of the project team would not attend. Thus, the conclusion is that project management and knowledge management can only go

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hand in hand. This conclusion was confirmed by the smaller units in the survey that exhibited good practices without having an official or explicit knowledge management program.

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