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Social practices and the management of knowledge in project environments

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Abstract

Increasingly, the importance of *social* aspects of knowledge retention and transfer has been emphasised in the literature on managing knowledge, with the recognition that knowledge is often tacit and situated and embedded within particular social groups and situations. This has considerable relevance for understanding attempts to manage knowledge in settings where activity and learning are project-based. Knowledge management in such a context faces many challenges, due to the one-off nature of project work and the many resulting discontinuities in methods of organisation and flows of personnel, materials and information. One important consequence is that social processes potentially play an important part in the diffusion and transfer of knowledge and learning. This paper sets out to examine the significance of social factors in enhancing knowledge management capabilities in such an environment, drawing upon case study research from the construction industry. The main finding from the research is that processes of knowledge capture, transfer and learning in project settings rely very heavily upon social patterns, practices and processes in ways which emphasise the value and importance of adopting a community-based approach to managing knowledge.

Keywords: Knowledge management; Social factors; Project-based learning; Communities of practice

1. Introduction

The potential importance of managing knowledge for competitive advantage has received a phenomenal amount of attention in recent years [1]. However, it is only comparatively recently that attention has specifically been directed towards the opportunities and limitations of managing knowledge in project environments [2–5]. This is somewhat surprising, as project organisation is not only an increasingly important mode of organising [6], but also has long been seen as the locale for complex processes of new product development and innovation [7].

Focusing attention on understanding knowledge management in project-based settings alerts one to the particular complexities associated with this form of organisation. Knowledge management in a context where learning is fundamentally project-based faces many challenges. As projects differ substantially from one another and significant discontinuities in flows of personnel, materials and information are created, it becomes difficult to develop steady state routines that maximise the flow of knowledge and the capture of learning from one project to the next [8]. In particular types of project setting—such as the construction industry, which is the focus of this paper—such discontinuities are added to by the fragmentation of the construction project team into different professional disciplines [9]. Each discipline has its own knowledge base and language, which can make the effective codification and transfer of knowledge even more problematic.

Although early debates on knowledge management tended to revolve around the use of information and communication technologies [10,11], the limitations of an IT-based view of knowledge capture and codification have long been emphasised [12]. Instead attention has increasingly shifted towards examining the role of the social community in promoting or inhibiting knowledge retention and transfer [13–19]. Although a good deal of knowledge within organisations may of course be amenable to the application of IT-based tools and techniques, approaches to knowledge management have increasingly explored the ways in which social structures and communities influence the capture and diffusion of knowledge and learning [13,14]. In this type of approach,

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much more emphasis is placed upon exploring the tacit and situated nature of knowledge and how it is embedded within particular social groups and situations [20].

The problem here, however, is that knowledge becomes very much more difficult to exploit, even when it can be clearly articulated, because it requires a shared system of meaning for understanding, accepting and deploying it. Conversely, knowledge may stick within firms and leak across firms, in so far as firms encompass multiple communities of practice [14]. Consequently, it becomes important to understand the ways in which social processes influence the nature of knowledge and learning, and the impact they have upon attempts to codify and commodify knowledge—including through the application of information and communication technologies. Having said that, there is very little detailed analysis available of the social mechanisms that support knowledge sharing, especially across projects and the communities that they link together [8]. In order to help understand further the impact of social processes on knowledge management in project environments, this paper therefore draws upon research recently conducted in the UK that was designed to explore knowledge management for project-based learning.[1]

The aim of the research was to identify likely enablers and barriers to effective capture and transfer of knowledge, drawing upon cases of single projects across characteristically different project environments. Although the study, as a whole, explored project-based learning across a range of sectors that included pharmaceuticals, telecommunications, health and social services [21–23], this paper draws exclusively from the one sector included in which project work was the *normal* mode of organisation—namely the construction industry. The particular case selected was the introduction by a contracting firm of new management processes, which were explicitly designed to encourage cross-project learning and knowledge sharing. Importantly, the company was attempting to develop explicit social mechanisms to encourage knowledge sharing and learning across projects, where traditionally this had been done in an ad hoc manner and where, more recently, the role of IT has been stressed. The case study therefore provides an opportunity to highlight and examine the significance of social factors in enhancing knowledge management capabilities in construction (as well as other) project environments.

2. Managing knowledge in project environments

Project-based organisations ought to benefit from the inherently innovative nature of project tasks. Since projects characteristically involve the development of new products and new processes, there are obvious opportunities for novel ideas to emerge and for cross-functional learning to occur, thereby enhancing the organisation's innovative capacity and potential [24,25]. Indeed, projects themselves are increasingly seen as vehicles for change in traditionally structured functional settings [6]. On the other hand, recent studies of knowledge management and organisational learning in project environments have emphasised instead the difficulties of learning from projects—not only within individual projects, but also across and between projects [2–4]. Crucially, problems of cross-project learning have wider implications for processes of organisational learning and, not surprisingly therefore, developing the capability to manage knowledge across projects is seen as an important source of competitive advantage for organisations [26,27].

Reasons for constraints on cross-project learning are not difficult to find. Project-based organisations face substantial obstacles to be overcome in capturing knowledge and in the re-cycling of project-based learning that stem from the relatively self-contained, idiosyncratic and finite nature of project tasks. Inevitable discontinuities occur in the flow of resources—especially personnel and information—across time and space, from one project to the next. Capturing and diffusing knowledge and learning across projects (or even between project phases) therefore becomes a major problem, as does avoiding the tendency to 'reinvent the wheel' when faced with a problem that needs to be resolved [3,28]. Additional complications emerge in the construction sector in particular due to the complex organisational division of labour between professional and other groups involved in the construction management process [5,9,29]. Such fragmentation has important implications for attempts to develop shared perspectives on innovation, knowledge and learning [13,30].

Overcoming barriers to effective knowledge management more generally involves a range of interventions, which reflect the various ways in which knowledge can be embedded within organisational systems and processes or embodied within the skill sets and competencies of individuals and groups [20]. Available approaches, however, can be broadly characterised in terms of a continuum ranging from what can be termed 'cognitive' to 'community' models of knowledge management [17]. The cognitive model stresses the codification of knowledge and is primarily concerned with its retention and circulation within the organisation via the application of information and communication technologies [10]. This approach, which is perhaps the most pervasive approach to knowledge management, is driven in large part by the increasing availability of information-based tools such as groupware and intranets.

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Indeed, much recent work on knowledge management in the construction sector still emphasises the opportunities and possibilities opened up with the application of such technologies [31,32]. However, many of the assumptions of this approach have been challenged by empirical studies, which question its emphasis on explicit knowledge and its predilection for knowledge codification through technology [16,17,19].

The community model focuses instead upon the tacit dimension of knowledge and, in particular, its embeddedness or stickiness within particular social groupings [18]. Tacit knowledge is difficult to exploit organisationally even when it is clearly articulated [33]. This is because to appropriate knowledge from someone else means having a shared mental model or system of meaning that enables the other to understand and accept that knowledge [34,35]. The diffusion of knowledge therefore involves developing some level of shared meaning that allows one group to understand and apply another's insights to their own context [16,25,36]. The community model therefore emphasises the importance of social networks and the cultivation of trust, norms and shared values amongst 'communities of practice' [13,14]. In communities of practice, knowledge is constructed as individuals share ideas through collaborative mechanisms such as narration and joint work. It is this process of constructing meaning through joint endeavour that provides organisational members with identity and cohesiveness and which provides the basis for effective learning. It is also important to recognise that the creation, diffusion and application of knowledge is situated and thus heavily influenced by the context of practice [37].

The importance of developing shared meaning and understandings, however, highlights the problems of inter-project knowledge diffusion and learning. In project settings, groups are temporally, spatially and culturally differentiated in ways that militate against the diffusion of knowledge via the development of well-established communities of practice. In such circumstances, the challenge may be not so much to make tacit knowledge explicit [26], but to work out how social practices are organised and to find ways of aligning them [14]. The immediacy of project objectives and the finite life span of project activity may act as a focus for innovative efforts. However, because they are highly task-focused, they also militate against the emergence of networks of actors who are able to construct such a community based on shared understandings. This is particularly the case in certain project environments—such as construction—where attempts to develop informal networks for the spread of knowledge and learning also inevitably cut across strong institutional, professional and contractual boundaries and demarcations [14,38]. Indeed, some have argued that such fragmentation has significantly restricted the innovative capacity of organisations in project environments such as found in the construction industry [5,39]. These conditions are likely to have a negative effect upon the 'absorptive capacity' of the organisation—its ability to recognise the value of new knowledge, assimilate it with existing knowledge, and apply it to commercial ends [40]. The need to fulfil immediate short-term project goals to meet diverse client aspirations (articulated through yet others' designs and specifications) inevitably perhaps confounds attempts to develop long term innovative capabilities within the individual contracting firm [5].

There remain therefore many unanswered questions about the nature of knowledge management in project environments and about the factors influencing project-based learning—particularly in a context affected by inter-organisational, contractual relationships. Principal among these is what part social processes play in the creation and diffusion of knowledge and learning and how these social processes relate to the use of technological and other mechanisms specifically intended to capture and transfer knowledge and learning from projects.

3. Research aims and methodology

In order to address this question, this paper draws upon research conducted as part of a study, which was designed to explore knowledge management for project-based learning across a range of industrial sectors in the UK. The research project as a whole took five case studies of projects being undertaken in the following sectors: construction, telecommunications, pharmaceuticals, health and social services. While the material presented and discussed here is limited to the construction case, the analysis and conclusions developed were also applicable more broadly across the cases. Further information about the other cases can be found elsewhere [21–23]. All of the projects investigated were concerned with the development of new products/services or the introduction of new management practices. However, as will be seen, the construction case was one of the latter. It did not involve examining, say, the construction of a new road or building. Instead, the research focused upon a recent reorganisation of engineering expertise within the firm. Nevertheless, it did exhibit distinct project characteristics—with specific objectives, a time-scale for implementation, a project manager/champion and systems for monitoring and evaluating the change. Consequently, the project examined here may have consisted of a change in internal management processes, yet it still constitutes a project—albeit one concerned with a change to generic management *processes*.

The research was interview-based and semi-structured in format. Interviews were conducted with seven managers

involved in the reorganisation—mostly senior engineering staff, but also staff from the operations side, including operations and engineering staff from both office and site level. All interviews followed a pre-designed interview protocol based on a six-page interview schedule, which covered the generation and capture of learning within the project and the inward/outward knowledge transfer to and from other groups in the organisation—including an assessment of the role of information and communication technologies. Open ended questions were specifically asked about: the nature of the project and the role of project team members; mechanisms and practices used for the communication and documentation of knowledge transfer and learning; broader structural/cultural characteristics of the organisations concerned; incentives and motivations for knowledge sharing; and effects on outcomes (knowledge transfer, learning and project performance). Each interview lasted approximately an hour and was tape-recorded. Data from the interviews were supplemented with background information obtained from archival material, including relevant organisational or project documentation.

4. The regional engineering manager (REM) project

The project involved the introduction of a new role—the Regional Engineering Manager (REM)—into a regionally divisionalised construction company. The aim of introducing the new role was to contribute towards profitability by increasing the value engineering of projects, as well as to improve the co-ordination of engineering services provision and engineers' training and development across the regions. The REM was therefore seen as a conduit for the spread of engineering-based knowledge and project-based learning throughout the company. As such, the setting up of the REM role can be understood as the establishment of a knowledge management mechanism in its own right, which draws upon engineers' experiences on past and present construction projects.

4.1. The context of the project

The construction company was a national contractor with an annual turnover of about £370m, consisting of £160m of building work, £150m civil engineering work, £40m of marine/water work and the rest in small projects and heavy plant provision. The company was split into four regions—the region where the research was conducted employed about 1200 staff. They used very little direct labour and employed regular consultants to provide design services. Over half of their work was done on a design and build basis.

The REM was a position first proposed 5–6 years earlier to facilitate communications among the regional offices and between the regional offices and the sites; and to assist with the tendering process, particularly in the area of value engineering. At the time of research, there were 10 REMs in the company in total—two in each region (one building, one civils), plus two in group companies. The creation of the REM role was part of a broader internal 'transformation process' that had begun in 1994/1995, and which saw the company attempt to change from a more adversarial approach to contracting to a more collaborative style. According to the company's Technical Director: "a lot of trouble we had got ourselves into, one way or the other, [was] due to bad engineering". Although a 'centre of excellence' in engineering had by then been established at head office, engineering in the regions (which were now established businesses) was perceived as not so strong and not so well connected in to the centre.

As the company was receptive to any suggestions for change at that time, it did not take much persuasion at board level to introduce the role and REMs were fairly quickly appointed. The REM had three key functions: to contribute towards putting together tenders, to value engineer tenders and existing projects, and to assist with the training and development of site engineers. The latter stemmed from the recognition that training and career development opportunities for engineers within the firm were limited. The position was therefore designed for a mid-level engineer—ideally someone who had been working with the company for a while and who knew the expertise available within the company. It was also envisaged as a career route—opening up career development opportunities within engineering, as opposed to the usual route via site management. Consequently, the original intention was to recruit entirely from within the company.

The role needed to be cost effective, as the costs of employing 10 REMs in the business amounted to about £0.5m per annum. Although financial savings targets were originally set when the position was first established, REMs now performed according to a list of 12 expected 'results'. These varied from the general (e.g. expecting them to be 'leaders within every business') to the more specific (e.g. establishment of a register of expertise). Many of these results revolved around key knowledge management activities, as the REM was expected to be the major conduit between the sites and regional office and a point of contact for site managers in case of any engineering queries, problems or requests for engineering advice or re-design. Without the REM, there was not much possibility of capturing and sharing knowledge and learning both between sites and between projects. According to one REM: "Knowledge transfer has been poor. The guys learn it and the only knowledge transfer is [on the] basis of senior engineers working with another engineer on the next job. It has been very, very informal and very poor". Indeed, in many ways REMs themselves were expected to be the embodiment of the collective learning capability of the organisation.

According to the Technical Director: "One of the reasons for the REMs was to have some sort of stability, some focus in the region. A long stayer, if you like, to develop the experience and the expertise in the business so that we are not re-inventing the wheel all the time."

Although generally regarded by those interviewed as a successful initiative, the REM role had not been without its problems and early difficulties were encountered in setting out a clear job description and in selecting appropriate staff. According to the Technical Director: "The accountabilities were a little vague, and so the REMs weren't sure what they were going to be doing, or what they should be doing". To counter these problems, more specific job descriptions were drawn up and more external appointments were made. However, there were still tensions in the role, which stemmed from differences between regions and differences in the emphasis put upon different parts of the job. In particular, there was a tendency for REMs to be more involved in the value engineering part of the role than in the longer term, more developmental aspects of the role where outcomes were less immediate and tangible. One REM estimated that the actual time spent on particular tasks (compared to what was intended) was 70% on tenders (compared to 40%), 15% engineering on live contracts (compared to 20%), 10% on training and development (compared to 30%) and 5% on linking skills on jobs (compared to 10%). The REM also did not directly manage any site engineers or other staff. This lack of direct control over staff meant that, to get things done, the REM had to matrix manage site engineers. This could cause them difficulties in getting their objectives accomplished and also meant that the REMs relied on a supportive climate to get others to assist them in their work. A further consequence was that their success depended significantly upon the skills and aptitudes of the person doing the job (especially communication and interpersonal skills).

4.2. Networking and modes of communication

In terms of the flow of information, knowledge and advice, the REMs in particular and the engineers in general relied heavily upon networks of personal contacts throughout the firm and beyond. E-mail was used extensively as a mode of communication and as a way of eliciting or distributing knowledge. One REM described for example how ideas might be circulated: "If I have a good idea, say, I do that on a report sheet then I will put it on the email to each of the REMs in all regions. They have then got the same information I have got." However, by adding that "It's up to the REMs to send that information", he also drew attention to one of the limitations of that type of communication and the fact that most communications tended to be more query-driven and reactive. Furthermore, it was very clear from the interviews that, although email was used, so too were other more traditional forms of direct contact. For example, although the company had an internal register of expertise, personal knowledge of whom to contact appeared to be much more important.

The importance of personal contact and networks showed itself in other ways too. REMs would meet together every 3 months at 'engineering forums' to discuss a wide range of issues and to build and reinforce personal contacts and networks. They also arranged bi-annual forums for site engineers who would meet to discuss project successes and failures, new jobs, current issues, grievances and the like. Apart from this, contact with engineers on site—to provide technical support and career advice—was frequent and informal. However, it was also sporadic and largely in response to particular queries that were raised. The ways in which technical knowledge was transferred between site engineers was therefore largely by word of mouth between staff from one project to the next. More formal processes, such as a system of 'quality alerts' linked to the BS procedures developed by the company's QA manager, did exist. However, this information did not always find its way to REMs or dovetail with other project review procedures.

With regard to the management of individual projects, REMs were less involved in formal project progress meetings, although they were more involved in pre- and post-contract meetings, including value engineering workshops. Through these, they had opportunities to communicate with clients and other external organisations. They were also able, to some extent, to draw upon technical expertise and information from networks of personal contacts with local firms of subcontractors and suppliers.

Although the company had a solid IT infrastructure and used e-mail regularly, the company Intranet and the engineering database it contained was not well used. According to the Technical Director: "I find it's easier to dial ... one of our regional offices, than it is to get on to the intranet". Apart from the lack of a standardised system, there were no incentives or resources to keep a centralised database up-to-date and accurate. As a result, there was still a very strong emphasis placed on direct, face-to-face contact and other, more traditional ways of communicating and transmitting information across the company. As the Technical Director put it: "In these days of electronic wizardry and technology, my opinion is that you can't beat a face-to-face, eyeball-to-eyeball meeting".

4.3. Enablers and barriers to knowledge capture and diffusion

Overall, therefore, there were a number of important factors that acted either as enablers or as barriers to the

effective capture and diffusion of knowledge via the REM role. Importantly, these centred rather less on the capture of knowledge through information and communication technologies and more on social processes and organisational factors. They can be summarised under six main headings.

4.3.1. Organisational structure effects

Since the drive to establish the REM role came from an established group at the centre and the location of the change project was within one discipline (engineering), any problems associated with communication across interdisciplinary boundaries were avoided. The size of the company itself enabled economies of scale in the use of certain mechanisms that encouraged cross-regional and cross-project knowledge transfer (e.g. the engineers' forums and training programmes).

On the other hand, in the early stages at least, REMs faced a lack of clear definition of roles and responsibilities. This role ambiguity could lead to a 'regression' to a more traditional engineering support role and the tendency for short-term business concerns to take priority over longer-term developmental needs. In practice, divisional operations directors' expectations of the role varied and immediate workload pressures often took precedence. Moreover, since the REMs employed no direct staff (and would be unlikely to be able to justify more help), they had no line authority over engineers and there was a lack of incentive to feed information back to the REM, other than on an as-needed basis. A heavy reliance was thus placed upon the REM being proactive and persuasive.

4.3.2. Cultural context and the climate for change

It was important that there had been a 'champion' in getting the change introduced in the first place (the current Technical Director) and who could then develop it further when there were early problems. Continuing support across the company as a whole was also important. Although REMs were expected to achieve a lot in terms of 'bottom line' results, it was clear that the climate for change was supportive and the company was generally receptive to the idea and to the business case made (and had recently relaxed financial targets). On the other hand, the level of support did vary across the regions, especially during the early stages when the role was first introduced. Moreover, there were still considered to be what one manager described as "pockets of resistance" and some concerns were expressed that recent restructuring changes would also have (unspecified) implications for the role.

4.3.3. Skills and capabilities

The importance of the style of those occupying the role meant that, on the positive side, REMs had considerable latitude in how they performed their role. On the other hand, it meant that a lot depended upon individuals' social contacts and informal networks (as well as their enthusiasm and personal skills in developing them). This emphasis on the importance of the individual occupying the role also meant that the company had needed to recruit from outside, thus reducing the internal career opportunities that the REM position was intended to open up.

4.3.4. Communications, networks and information flows

The establishment of a network of REMs throughout the company (each with their own external networks and contacts) provided a base of information, knowledge and support that individual REMs could draw upon to help them diffuse ideas and expertise within their own regions. On the other hand, contact between REMs within the firm (and between REMs and engineers), although quite frequent, was rather irregular, informal and ad hoc and very much in response to specific queries. The geographical separation of sites, both from one another and from the regional offices still had a detrimental effect on the diffusion of knowledge because of the importance placed on social networks and contacts. There were also a number of other barriers to the flow of knowledge, information and advice. These stemmed from: contractual constraints on the free flow of knowledge and expertise; the lack of integration of separate information flows (e.g. the separate 'quality alerts' system); and the lack of mechanisms for capturing project learning (post-project reviews were described by one REM as more like 'post mortems').

4.3.5. Technological mechanisms

E-mail systems were clearly an important enabler of communication, especially between REMs, but also (potentially) among sites and between sites and regional offices. However, there were a number of problems identified with regard to the use of the intranet and web-site within the firm. These included lack of standardisation of the system, practical difficulties in accessing the intranet and web-site from site offices, the lack of incentives to use and up-date information on the web-site and the lack of resources to keep the web-site up to date and accurate.

4.3.6. Objectives and outputs

Clearly set out objectives for the role, although some were not so tangible and explicit, did nevertheless provide a framework for assessing the role and for monitoring and appraising REM performance. However, while the emphasis on value engineering did mean the very direct application of engineering knowledge to immediate practical business problems, it also potentially inhibited aspects of the role that were related to the longer term accumulation and development of engineering knowledge.

5. Discussion

The first and most obvious point to make about the case concerns the nature of the project itself and the fact that it concerned a management reorganisation, rather than the development of a new product or service. Not surprisingly, much existing research on project-based learning tends to focus on product innovation [41]. However, the construction case was primarily concerned with process innovation. Indeed, this was true of all the other projects looked at in the research—even where the delivery of new services was the main aim of the project (as in the pharmaceutical and health sector cases). Consequently, it may be difficult to disentangle the effects of product and process innovation in the case of many types of project, making it possible that product innovation depends inevitably upon a certain degree of process innovation, making the two mutually dependent [23].

This point is also important, because what emerges from the construction case (and from others—see [21,23]) is that process innovations such as the REM pose particularly difficult problems for knowledge capture, diffusion and learning. Learning in product innovation projects tends to follow a convergent logic: diverse sources of knowledge are progressively integrated within a single product or service specification. Learning can therefore be captured and more easily transferred in explicit forms—via product design templates, for example. In the case of process innovation, on the other hand, what the REM case demonstrates well is that what is learned is often tacit, intangible and context-dependent (e.g. involving changes in work practices, roles and responsibilities and attitudes and values). Such learning is not only difficult to measure and evaluate, it is also difficult to capture in explicit forms, in ways that can be understood and applied in new contexts (or even applied consistently across different parts of the firm, as the REM case demonstrates). The resultant knowledge and learning is also easily re-interpretable and subject to the vagaries of the political climate for change [42,43]. This makes it easily malleable and gives it an esoteric and perhaps ephemeral quality that may make it not only difficult to embed within organisational systems and standard routines, but also difficult to enculture within wider collective organisational norms and values [20].

One implication of this is that process innovations, perhaps more than product innovations, depend crucially upon the context and environment for change, as well as upon the nature of the change process itself [44]. Certainly, many studies have highlighted the importance of the wider organisational context for the capture and dissemination of knowledge and learning [45]. Clear evidence emerges too from this case study of the importance of a committed project champion [46] who was able to span internal boundaries and represent the case for change to a wider organisational constituency. It was evident too that a shared ideology and vision of change [47] created the right conditions for the development of a case for the project based upon an agreed-upon set of objectives. It was also important that the introduction of the role was backed up with the provision of appropriate and adequate resources [26]. Having said that, it is also important to stress the inherently political nature of this context. The fact that the introduction of the role complemented and echoed an internal discourse that favoured change was highly significant [48]. So too was the requirement to present a convincing business case that managed to align short term, tangible outcomes with long term, developmental aims.

Another implication of the difficulty of embedding or enculturing such knowledge, is that success depends crucially upon interpersonal and social aspects, rather than technological or procedural mechanisms [49]. Regarding the role of information and communication technologies, the case illustrated well some of the key limitations of the use of IT and formal procedures in diffusing engineering knowledge and learning throughout the network of REMs and engineers. Attempts to manage knowledge certainly included the use of documentation and electronic means (the Intranet and e-mail). However, the case not only demonstrated some of the practical difficulties in using electronic means to link geographically diverse teams (particularly across sites), but also lay stress on many of the behavioural factors that influence the use of such technologies [50,51]. Key problems here were the difficulties in motivating or encouraging staff to use and refresh the databases available [52,53], as well as the strong predilection for reverting to interpersonal forms of contact whenever new information or knowledge was needed.

Indeed, what emerges from the case overall is the much greater importance of social and behavioural processes, as opposed to the use of technology or procedure aimed at the codification of new knowledge [49]. What became clear was that the importance of the tacit elements of knowledge and how to acquire it, coupled with the limits on being able to codify that knowledge, meant that knowledge tended to be embodied and embrained [20] in members of the network of engineers within the firm. Indeed, REMs themselves were presented as the embodiment of the 'corporate memory' for engineering expertise. The importance attached to personal networks for accessing knowledge, the value attached to regular discussion forums and the significance of the movement of engineers from one project team to the next as the main mode of cross-project learning all reinforced the importance of the social dimension.

Particularly important perhaps, were the shared meanings and understandings about the needs of engineers

within the firm and how these needs were likely to be met by the new role. Not only did a shared concern with disseminating information, advice and support help bind together the network of REMs, it also spread to encapsulate engineers distributed across sites within the organisation (indeed, site engineers interviewed were very positive about the supportive aspects of the new role). Reinforcing norms of knowledge sharing was therefore a vital part of the success of the initiative. Of course, not all projects are located within single disciplines and what commonly distinguishes project organisation is precisely the difficulty experienced in integrating cross-functional contributions and perspectives [54,55]. However, the point here is that, even within this more unitary context, success in diffusing knowledge and learning still depended upon developing a shared vision for the role, as well as appropriate norms of knowledge sharing. These were therefore important cognitive and relational aspects of the efforts required of REMs in leveraging the available 'social capital' [56] among engineers within the firm.

The networks and social contacts of individual engineers were also an important basis upon which the success of the REM role depended. Clearly, the extended networks of engineering staff—both within and beyond the firm—were important as a means of accessing and circulating knowledge regarding technical developments and, thus, potentially important ways of enhancing the firm's absorptive capacity [40]. Indeed, it could be argued that networking across the organisation and beyond it is crucial in process innovation projects that, by definition, cut across existing processes and routines. Consequently, it was important that REMs were able to act as 'knowledge brokers'—bringing together their own personal networks (which included information sources from outside the organisation) and connecting them to the operational side (via their direct role in tendering and their role in supporting site engineers). Wenger [57] describes the roles of 'boundary spanner' and 'roamer'—both of which apply well to the performance of the REM role. The case study therefore helps confirm the importance of strong network ties for the sharing of tacit knowledge and of non-redundant weak ties for accessing explicit knowledge from elsewhere [58].

Having said that, the case study also illustrates a peculiar dilemma in this respect. The creation of an internal network of REMs, based on strong or redundant ties [59], may be perfectly appropriate for accessing local knowledge from within the firm that has not yet been articulated or codified in any way [58]. However, tapping into complex new knowledge—for example, about a new method of construction—may be much more problematic, if that knowledge is only available elsewhere and largely in tacit form (from consulting engineers known to the REM, for example). The dilemma here is that the greater the cohesion associated with the development of an internal network (desirable in terms of people 'buying into' the system), the more likely this may be to encourage localised search behaviours. Such search behaviours, however, may not be as productive a source of new ideas, or as efficient a way of accessing them. In other words, there is a delicate balance between encouraging the development of a network based on strong, but redundant ties, while at the same time, encouraging the maintenance of other, potentially very useful networks that are based on weak, but non-redundant ties [58]. Moreover, there is also the danger of reinforcing an inward-looking perspective. As REMs start to define and identify themselves as part of a new community of practice, in which informal practices become more important than those prescribed in the original role, there is the prospect that the group as a whole becomes ever more inward-looking. Such a tendency to build upon successful internal social relations may well be at the expense of, rather than complementary to, developing a more outward-looking approach that accesses alternative sources of knowledge and learning.

Furthermore, the reliance on the individual and their tacit knowledge and personal skills as the mainstay of the network raises two inter-related questions about the long-term implications for project-based organisational learning in this type of context. First, how is the organisation able to capture learning and deploy it over the long term, when it is so embodied in the individual and manifested in their particular expertise and range of contacts? Second, what happens when the individual leaves and takes their knowledge and contacts with them? It was unclear from the case how the expectation that the REM embodied the collective corporate memory was to be effectively realised over the long term (researching such a matter was also well beyond the scope of the current study). What was clear, however, was that the emphasis on the individual embodiment of engineering knowledge and expertise militated against the transfer of such knowledge, except perhaps through the mechanisms of various forms of socialisation and mentoring [1,30]. Whether such support systems were in place and how effective they were, however, was questionable, given the tenor of the case data, which suggested that such additional resources and support may not have been readily available. More generally, this point draws attention once again to the human resource constraints on knowledge transfer and learning and how they can be further exacerbated by circumstances within project settings.

6. Conclusion

This paper has set out to explore knowledge management processes associated with project-based learning,

by drawing upon a case study of organisational change in a construction company. The main finding to emerge from this case is that processes of knowledge capture, transfer and learning in project settings rely very heavily upon social patterns, practices and processes in ways which emphasise the value and importance of adopting a community-based approach. These findings have obvious implications for introducing new managerial initiatives in a project environment such as construction, in that they illustrate the difficulties, challenges and limitations of attempting to capture and codify project-based learning via the use of technological mechanisms (specifically, IT). They also illustrate the importance of trying to develop mechanisms for knowledge diffusion that are able to replicate the social nature and dynamics of knowledge management and learning processes.

Indeed, the study suggests further that developing absorptive capacity for *process* innovation creates particular challenges, since project learning depends as much on transferring elements of the context and social processes which create the learning outcomes as on transferring the outcomes themselves. Thus, whereas the development of product innovations can be well recorded through design iterations and artefacts, process innovations are less likely to leave such a trail and more likely to generate tacit or informal procedural knowledge. Learning capture then becomes more dependent on the identification of comparable problems/opportunities that the project team's experiences could be applied to, the representation of those experiences as stories of success or failure, and the incorporation of learning into new routines which can be applied elsewhere.

A final point to note is that these findings relate not only to construction, but can be generalised to other project settings. The research project as a whole demonstrated how, despite considerable sector diversity, the organisations experienced remarkably similar barriers and enablers to managing knowledge for project based learning [21–23]. In particular, generating shared meanings and understandings amongst those involved, the importance of social networks and personal skills and a supportive internal climate and/or strong champion of change were features that enabled change across the cases. A good example of this was in the health service case. The development of a successful new cataract treatment process crucially depended upon a group of key medical and nursing staff committing themselves to a project initiated by hospital administrators, championed by a consultant and which required them to accept changes to professional demarcations [23]. Conversely, in all of the cases, examples could be found of the limits of technological and procedural mechanisms and the difficulties associated with internal structural barriers and political divisions. In the telecommunications case study, for example, the development of a sophisticated information retrieval system to help a group set up to monitor innovation in the sector was not widely utilised because, according to one project manager, "[people prefer] personal email, the coffee point and meetings" [21]. The pharmaceutical company showed how, in contrast to the health service case, the development of a radical new procedure to treat prostate cancer was inhibited by the difficulty in getting radiologists and urologists to work together on the project [22]. Space limitations make it impossible to conduct a full cross-sector analysis in this paper and more research is also obviously needed to explore such cross-sector similarities and differences in more detail and using a variety of methodologies [60]. However, the above examples should give more than a flavour of the ways in which such lessons learned about the importance of social processes and the effects of context apply not only to construction, but equally well to a wide variety of project environments.

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