EXPLORING DIVERSITY IN MULTIDISCIPLINARY TEAMS

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Abstract

The uniqueness of multidisciplinary teamwork is in its potential to integrate different bodies of knowledge into a new synergy. However, previous empirical studies have shown that member heterogeneity and geographic separation hinder effective sharing and use of team knowledge. The paper explores how such teams interact to overcome the barriers and take advantage of their "built in" knowledge diversity. The empirical data for this study was gathered through multi-method field research of five dispersed multidisciplinary teams. The findings indicate that often teams lack common background knowledge at the beginning of the projects and in order to resolve differences members rely on their external intellectual and social communities. The reported research establishes a positive correlation between team members' participation in multiple professional and social networks and teams' abilities to successfully build on their knowledge diversity. The findings also suggest a need to reconceptualize the boundaries of multidisciplinary teams and to consider the processes of sharing diverse knowledge in a wider social context.

Keywords: Multidisciplinary Teams, Knowledge Diversity.

Exploring diversity in multidisciplinary teams

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1. Introduction

With the intensification of globalisation and expansion in the use of information technology, particular attention is being focused on the opportunities and difficulties associated with sharing knowledge. The exponential growth of knowledge has made it nearly impossible for any organisation to exist in isolation. Thus, the networked organisation or alliance is becoming an increasingly common structural form (Leonard et al. 1998, Gulati, 1998). Such networked organisations are usually described as collection of organisations and individuals that have entered into collaborative relations usually involving multiple channels of communication and knowledge diffusion across disciplinary or organisational boundaries. The focus on knowledge is particularly acute in the context of geographically distributed multidisciplinary teams, where the development and delivery of timely and innovative products across heterogeneous cultures and markets are critical and ongoing challenges (Orlikowski, 2002).

While the potential advantages of multidisciplinary teams, in terms of creative potential and effectiveness, are theoretically attainable, empirical evidences suggest that knowledge diversity constrains effective sharing (Boutellier et al. 1998; Gorton and Motwani, 1996; Madhavan and Grover, 1998; Prokesch, 1997; Brown and Eisenhardt, 1995). These constraints have both occupational and contextual origins. Differences in perspectives, priorities, typical approach to problem solving and professional language can hinder understanding and team cohesion (Doughety, 1992). These difficulties of managing knowledge exchanges amongst team members can become major barrier to any successful multidisciplinary operation. Previous studies (Doughety, 1992) established that all these 'interpretive barriers' might be resolved through team members engaging in highly interactive exchanges.

While previous studies on knowledge processes have examined a variety of settings, most have focused on the work practices of individuals (Orr, 1996) or that of focal groups proximate in time and space (Pentland 1995, Cook and Yanow, 1996). The literature on multidisciplinary teams is very limited and fragmented at this point. Providing a rational-structural definition for this type of teams, recent studies focused mainly on the team's composition aspects (Nonaka and Takeuchi, 1995; Duarte and Snyder, 1999). For example Nonaka and Takeuchi do not attend to the question of how and why would knowledge conversions take place and what processes will enhance or interfere with this

task's performance. Spender (1998) argues that you cannot talk about knowing (and thus knowledge conversations) without probing the concept of the knower. Looking, therefore, only at the composition of the team is a very limited approach towards understanding the dynamics of multidisciplinary teams where knowledge conversations are taking place.

Little is known about the process of knowing in complex organizations that are also geographically distributed. The complexity, multiplicity and dispersion of such settings complicate how we think about and study knowledge processes. An important contradiction emerges between the embedded nature of knowledge and the mobility of knowledge in geographically dispersed settings (Clarke and Fujimura, 1992). On one hand, the authentic knowledge processes are somehow embedded within specific practices and interpersonal exchanges, on the other, the successful use of electronic infrastructure to support knowledge processes depends on knowledge being made mobile and transferable across people located in different places.

The paper explores how geographically distributed multidisciplinary teams interact to overcome the communication and cultural barriers and take advantage of their 'built in' knowledge diversity. Dealing with such challenges requires more than just balanced team composition of experts in different fields, it also requires a deep competence in "distributed organizing". The focus of the paper, therefore, is on the processes of organizational knowing as emerging from the ongoing and situated actions of team members as they engage with the world, rather than "knowledge" as an outcome of team's activities. In order to be able to address the contradiction between the embedded nature of the processes of collective knowing and the requirement for higher mobility in distributed settings, the author adopts the view that understanding the intra-teams' dynamics requires considering teams in a wider context and acknowledging relationships with various external stakeholders.

The empirical data for this study was gathered through multi-method field research of five dispersed multidisciplinary teams. The findings indicate that often teams lack common background knowledge at the beginning of the projects and members are accustomed to different working practices. Therefore, in order to resolve differences members rely for support on their external intellectual and social communities. The reported research establishes a positive correlation between team members' participation in multiple professional and social networks and teams' abilities to successfully build on their knowledge diversity. The findings also establish a need to

reconceptualise the boundaries of multidisciplinary teams and to consider the processes of sharing diverse knowledge in a wider social context.

2. Factors affecting multidisciplinary operations

Multidisciplinary teams are believed to be useful in developing innovative and optimal solutions to many types of business problems (Cohen and Mohrman, 1995). It has been previously argued that the complementary expertise in multidisciplinary teams can contribute to faster problem solving, enhanced capability to address complex problems in a creative way and most importantly create new knowledge about products and processes (Madhavan and Grover,1998; Boutellier et al, 1998). However, previous studies (Alavi & Yoo, 1997; Cramton, 1999; Cramton & Webber, 1999; Leonard et al, 1998) provide limited insight into the effects of team geographic dispersion. As much of this research stream focuses on the role of technology in supporting remote communication, team members are often selected on the basis of physical location rather than because of specialized expertise. Previous studies conclude that even in the absence of occupational or functional diversity geographic dispersion can aggravate the complexity of collective work and negatively affect groups' communication (Cramton et al. 1999). Cramton (1999) also found that dispersed student teams (connected through technology) with similar educational backgrounds lacked 'mutual knowledge' of each member's local context and constraints, and this hindered their ability to work together effectively. By assuming that remote partners experienced the same circumstances they themselves experienced, team members failed to recognize the root causes of miscommunication, and therefore attributed their remote partners' behavior to dispositional rather than situational factors.

The results of previous studies are divided about the impact of geographic dispersion on teams' interactions and performance. Some authors support the view that the demographic diversity is not beneficial in itself, but only to the extent that it represents other diversity, such as of information, values, or perspective (Jehn et al. 1999). Earlier studies found that demographically diverse groups outperform homogeneous groups (Hoffman, 1978), while too much similarity and group cohesion can result in groupthink with its associated performance losses (Janis, 1982). In contrast, some research (Ancona and Caldwell, 1992; Williams and O'Reily, 1998)

concludes that increased diversity in working groups and project teams may have dysfunctional effects on group process and performance. In addition, members' similarity in demographic characteristics has been positively associated with team effectiveness and interpersonal attraction (Hambrick and Mason, 1984; Tsui et al. 1992), and homogeneous members report stronger affinity for their teams than heterogeneous team members (Ibarra, 1992). In general, the relationship between group heterogeneity and performance is mixed – and most likely depends upon task and contextual factors (McGrath, 1984; Williams and O'Reily, 1998).

The lack of agreement about the factors affecting multidisciplinary operations raise a question about how distinctively different such multidisciplinary, computer-mediated interactions are from other forms of network relationships (Staples et al. 1999; Ratcheva and Vyakarnam, 2001; Kraut et al. 1999). The author adopts the view that the geographically dispersed multidisciplinary teams are not simply an evolutionary development of collocated entrepreneurial or new product development teams and they represent new patterns of interactions. The differences, however, do not purely result from the different locations and variety of communication media used, but more importantly from the different patterns of social exchange, conveying social messages, developing inter-personal and trustworthy relationships, therefore factors which can critically affect the individual willingness to actively share personal knowledge.

3. Integrating heterogeneous knowledge in multidisciplinary context

In spite of the apparent advantages of designing teams for knowledge diversity, it is by no means clear how team members make effective use of this knowledge. Grant's (1996) observation, which this paper aims to extend, is that knowledge integration, not knowledge itself is what generates an advantage for organisations and respectively teams. Penrose (1959) cautioned that the search for knowledge is so voluntary and deliberate, yet so much a part of normal operations that it cannot be left outside of our system of explanation. Although, the organisational form and structure provide the 'bones', it is group-level knowledge integration that provides the 'flesh and blood' (Van den Bosch et al. 1999). As new product features are added, new types of specialized knowledge may be required (Penrose, 1959). As new knowledge is brought in on an as-needed basis, it must be integrated with the existing base of knowledge held by the

team members. This is perhaps the most compelling explanation for why some teams comprised from the ‘smartest’ and ‘brightest’ experts still fail to perform well. Although the aggregate level of knowledge in such teams might be high, their lack of ability to integrate that knowledge can keep them from gaining any benefits from that resource pool.

Knowledge integration is defined as the project team’s ability to continually bring its members’ and new external knowledge to collectively bear on the project’s execution. Individually held specialist knowledge is synthesized into a new project-specific architectural knowledge. Grant (1996) describes this act as integration; others have referred to it as combination (Kogut and Zander, 1992), configuration (Henderson & Clark, 1990), and recombination (Galunic and Radan, 1998).

Previous research studies indicate that team’s ability to integrate diverse knowledge domains is primarily influenced by the differences/commonalities in the individually held occupational and contextual knowledge. For example, individuals trained in a particular discipline, function or occupation have substantial conceptual and practical knowledge in common with others from that discipline or occupation (Fleck, 1997). They share terminology and mental frameworks (Vicenti, 1990) which facilitate the efficiency of communication among them. Different occupations, therefore, act as distinct ‘thought worlds’ (Douglas, 1986), have different funds of knowledge (what members know) and systems of meaning (how members know). Dougherty (1992) applied these concepts to organisational departments undertaking product development, and noted that, even though different functional communities were exposed to the same product development circumstances, team members from different functions understood those circumstances differently, selectively perceiving certain aspects as salient and drawing different implications. Recent research (Bechky, 1999) has focused on occupational knowledge particular to different communities such as engineers, technicians, and operators. Bechky (1999) suggested that even within the development function, occupational knowledge is sufficiently diverse as to require ‘translation’ in order for adequate understanding to emerge.

Other organisational researchers have focused on the relationships between particular context and the unique knowledge acquired in this way (Fleck, 1997; Tyre and Hippel, 1997). Contextual knowledge, therefore, pertains to the broader milieu of the working environment (Fleck, 1997). Many authors have noted the existence of

knowledge that resides in systemic routines or ways of interacting, describing such knowledge variously as ‘organising principles’ (Kogut & Zander, 1992), ‘embedded knowledge’ (Badaracco, 1991; Granovetter, 1985) and ‘organising routines’ (Levitt and March, 1988; Nelson and Winter, 1982). Contextual knowledge is developed through repetitive collective actions and is “expressed in regularities by which members cooperate in a social community” (Kogut et al. 1992). It comprises knowledge of appropriate methods and resources, contributing to communication and task efficiencies and task effectiveness by leveraging taken for granted meaning associated with particular behaviour within a specific setting. These associations and behaviours are learned over time from working in a specific setting, and so they are unlikely to be common knowledge among people who are not co-located. In addition, because contextual knowledge tends to be taken for granted by members of a community, it is not easily articulated to members of other communities.

Although previous research acknowledges that different prior knowledge is an integral part of any multidisciplinary operations and teams’ abilities to integrate it is a dynamic process, still little is known about how interactive relationships between team members evolve, develop and change and how factors associated with geographic, cultural and occupational diversity impact such processes.

4. Theoretical story line

The ability of a project team to integrate its members’ component knowledge into architectural knowledge influences its ability to execute a project successfully. Given that a larger proportion of component knowledge is held tacitly at an individual level in the form of know-how, specialized skills, and individual expertise, the ability of the multidisciplinary team to integrate it largely determines the extent to which it can bring that knowledge to bear collectively on the project execution. As previously mentioned, the knowledge creation processes are socially constructed and therefore the articulation of the tacitly held individual knowledge into a higher level collectively developed concepts, requires an appropriate context which can enable such processes to take place. However, recent studies predominantly focus on enabling context which resides inside companies organisational boundaries and therefore the new knowledge creation processes are well embedded in the organisational culture, routines,

established procedures, etc (Nonaka and Konno, 1998). The social interactions in a distributed environment are rather different and more recently writers started to advocate to consider virtualisation as a major social process (Diemers, 2000). The virtualisation, therefore, requires major reconceptualisation of organisational roles, norms and culture which traditionally use to constitute the environment in which social interactions took place. In contrast to the 'real' environment in which face to face social interactions take place, the virtual networks are only media platform, where according to Harisim (1993) common interpretative spaces of social networks constitute social spaces.

Furthermore, because of the temporally nature of teams, the embedded, tacit practices and routines of working together must be recreated every time because of the non-persistent social structure. The structural context must compensate for the loss of those social threads (Jarvenpaa and Tiller, 1999; Jarvenpaa and Tiller, 1999). Distributed teams, therefore, require design structure and relationships that are as agile as their markets are dynamic (Gilliers, 1999). Unlike collocated teams operating in stable organisational environment that largely depend on learning-before-doing (knowledge stocks), virtually operating teams must also integrate new and emergent knowledge in real time (learning-while-doing). Quick adaptation to market, technological and environment changes is therefore vital (Keil and Montealegre, 2000).

Based on the argument that knowledge can be integrated only by teams or groups, the ability of a multidisciplinary team to execute project successfully will be positively associated with the team's ability to integrate relevant knowledge, expertise and skills that might be distributed amongst team's members. An underlying assumption in the development of this study was that dispersed multidisciplinary teams represent novel patterns of information exchanges and relationships. The argument, therefore, developed in this study is that multidisciplinary team development and inter-personal processes are likely to follow specific development and adjustment patterns because as members are part of different organisational cultures, they will bring different expectations about work relationships and perceptions of success. Successful knowledge integration processes will be therefore largely determined by three complementary team attributes that together constitute teams' interaction context (see Figure 1): (1) interpersonal interactions and relational capital developed amongst members, (2) work organisational practices and procedures and team's ability to

recognise, interpret, and value information from across its web of participant business units and the external environment, (3) cross-cultural communication behaviours.

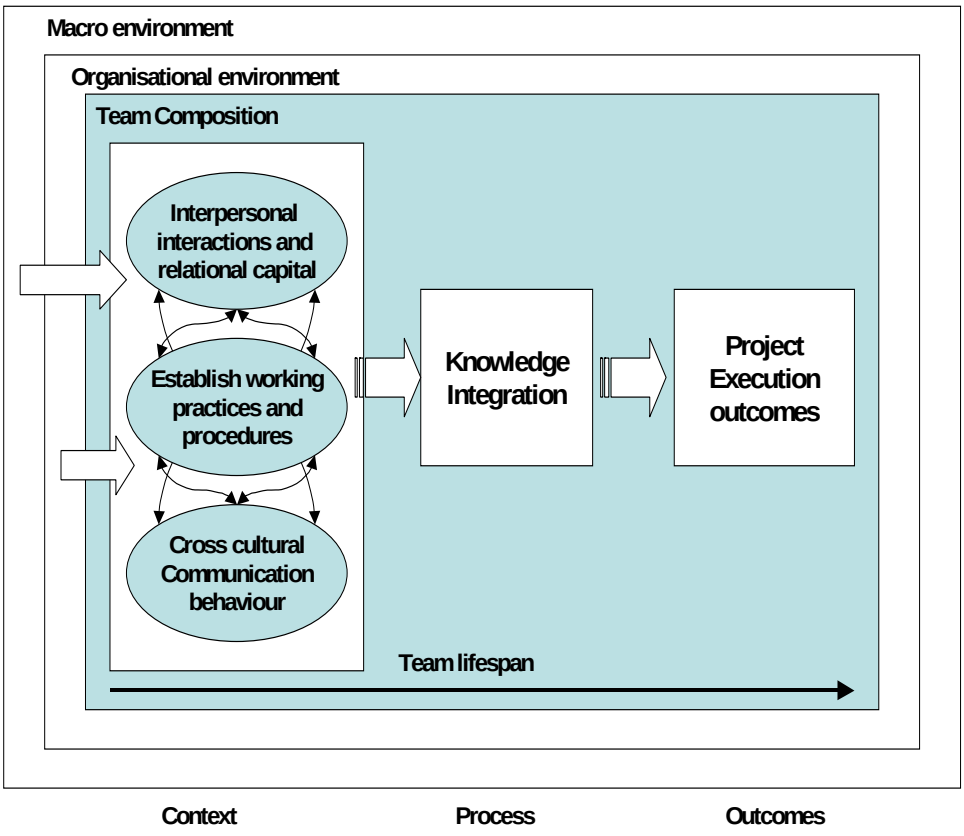

Fig. 1 Conceptual framework

4.1 Interpersonal interactions and developing relational capital

Relational capital is defined as level of trust, reciprocity and strength of ties among the members of a project team (Kale et al. 2000). Furthermore, relational capital at the team level is influenced by the business units (or organisations) from which those members are drawn. Each unit brings in unique expertise, strengths, and knowledge that must be integrated in the context of the project. As members are drawn from these units to form a project team, they effectively form a web of relationships among individuals that extend

to their parent subunits, units, and organisations. This set of linkages can be described as a relational web.

Integrated team capabilities, therefore, depend as much on the individuals' abilities to work together (develop relational capital) as they do on their individual expertise and skills. Strong, trusting, and active relationships within project teams reduce the costs of communication, coordination, and combination of individual expertise at a project level (Kogut and Zander, 1996).

Strong relations facilitate close interactions amongst project team members of different organisational origins (Kale et al. 2000). Close interactions are instrumental in synthesizing sticky, tacit knowledge across organisational boundaries. Higher levels of relational capital are therefore associated with higher levels of learning and knowledge integration between dyadic partners or among members of a relational web.

The willingness of team members consciously and actively to perform their duties critically depends on developing trustworthy relationships. In an environment without formal control and coordination mechanisms trust has been described as a 'heartbeat' which can prevent geographical and organisational distances of team members from turning into unmanageable psychological barrier (Jarvenpaa and Stamps, 1997). The literature acknowledges the existence of impersonal or institutional forms of trust in virtual teams in addition to interpersonal forms. According to Luhmann (1986) impersonal trust is based on the appearance of "everything in proper order", rather than on an emotional bond, knowledge or past history of interactions. Meyerson et al. (1996) developed the concept of 'swift' trust to explain how temporary teams can enjoy high levels of trust, even through members do not share any past affiliation and can not necessarily expect to have any further associations. The concept of 'swift' trust maintains that "unless one trusts quickly, one may never trust at all" (Meyerson et al. 1996). Because there is not a sufficient time to develop trust through interpersonal means, team members import expectations of trust based on their local organisational environment, industry practices or role based stereotypes. Positive expectations of trust motivate members to take a proactive part in the team, which can result in strengthening the trustworthy relationships amongst team members. Relational capital, therefore, serves as an effective, cost-efficient, and self-enforcing mechanism that improves knowledge integration while simultaneously discouraging opportunism in a relationship web.

4.1 Work organisation practices and routines

Time, Interaction and Performance theory (TIP) (McGrath, 1991) represents an emerging trend in small group research which takes into account the new, temporally oriented tradition. Work in this tradition treats groups dynamically and attempts to take full account of the physical, temporal, and social context within which those groups are embedded.

McGrath's (1991) TIP theory describes work groups as time-based, multi-functional, and with multi-modal social systems. Effective groups are engaged simultaneously and continuously in three functions: 1) production (problem solving and task-performance), 2) member-support (member inclusion, participation, loyalty, and commitment) and 3) group well being (interaction, member roles, power, and politics). Teams carry out three functions by means of activity that relate to four possible modes: (Mode 1) inception and acceptance of a project, (Mode 2) problem solving, (Mode 3) conflict resolution, and (Mode 4) project execution. The modes/functions, according to McGrath and Hollingshead (1994), are not a fixed sequence of phases, but dependant on the team, tasks, technology, time, and other environmental contingencies. The TIP theory suggests that a team with no past history which is working on a challenging problem with much technological and environmental uncertainty has to engage in all four functions and modes to avoid detrimental effects on performance.

Multiple involvement in various functions and tasks and, therefore, low division of roles in a virtual team can enhance the team's integrity and consequently to enhance the team's performance.

4.3 Cross-cultural communication behaviours

The culture specific behaviours of individuals brought to work on cross-organisational projects are also likely to have a significant impact on team's integrity (Gudykunst, 1997). One dimension of a cultural variability identified to have an impact on ability to work successfully in a team is individualism-collectivism (Hofstede, 1991). In individualistic cultures, the needs, values, and goals of the individual take precedence over the needs, values, and goals of the in-group. Opposite, in collectivist cultures, the needs, values, and goals of the in-group take precedence over the needs, values, and goals of the individual

(Gudykunst, 1997). Empirical findings suggest also that individuals from individualistic cultures tend to be less concerned with self-categorising, they are less influenced by group membership, have greater skills in entering and leaving new groups, and engage in a more open and precise communication than individuals from collectivist cultures (Hofstede, 1991). Previous cultural exposure has also been identified as an important factor influencing communication behaviour.

Team members import working behaviour from other settings with which they are familiar. Therefore, virtual team members representing organisations with strong collectivist cultures are more likely to develop strong social bonds over a longer period of time and less likely to involve in a more open communication in contrast to individuals representing individualist organisational cultures.

5. Research methodology and sample definition

Five small and medium size companies in UK took part in a longitudinal qualitative study investigating the team development processes which enable or hinder the diverse knowledge integration in geographically dispersed multidisciplinary context. The results presented in this paper are the preliminary outcomes of the second stage of the research project specifically focusing on successful practices in integrating diverse knowledge which resulted in novel products, procedures, processes, etc. A common characteristic of the sample companies is that they went through major strategic and structural change processes during the late 90's in order to maintain their competitive positions. These change processes revolved around a re-definition of the vision and identification of key areas where innovations and work process improvements could continually support the companies' strategic edge (see Table 1 for companies' background information). One of the outcomes of the restructuring initiatives was the increased reliance on multidisciplinary virtual teams to handle a variety of business initiatives, formed across organisational and country boundaries.

Cases	Main activities	Team boundaries	No. of team members
Case 1	Engineering and software project consulting	Different organisations, operating in 2 countries	8
Case 2	Engineering consultancy	Different organisations, operating in 3 countries	7
Case 3	Electronic modem assembly	Different organisations, operating in 2 countries	9
Case 4	Assembly of electronic connectors	Different organisations, operating in 3 countries	10
Case 5	Research and development engineering consultancy	Different organisations, operating in 3 countries	7

Table 1. Companies' background

Case 1: Engineering and software project consulting

The company was established in 1992 by 3 computer engineers as an engineering consultancy. The company currently plays (since 1995) the role of a project integrator for small manufacturing firms in the region by identifying for them European and UK based projects and assessing their production compatibilities using interactive graphical simulation software packages. The company currently employs 11 people and it has doubled its turnover for the last 3 years, currently reaching £13,000,000. Since 1997 they have developed a database with over 60 small manufacturing companies mainly in UK and France which are potential partners in different projects. The team members in the business have similar educational and professional background and share responsibilities for major projects.

Case 2: Engineering consultancy

This private company was established at the beginning of the 80's, originally specialised as a precision metal manufacturer for the aircraft industry. Because of the reduction in the defence budgets and the manufacturing sector's severe recession in the early 90's, the

owners started to look for new opportunities. The appointment of two PhD graduates gave the company expertise as a consultancy for 3-dimensional computer aided design. Today the company employees 20 engineers and technicians (respectively 44 employees in 1993) and is involved in a number of project partnerships in the aircraft industry, wind energy technology and automotive industry.

Case 3: Electronic modem assembly

The company was established in 1994 by five university graduates. Initially they were involved primarily in manufacturing of electronic modules for telephone lines, portable computers and organisational desktops. In 1997 they gradually started to subcontract out some component production because they faced serious difficulties in recruiting people with the required expertise. As a result the number of components in each modem has been substantially reduced which resulted in increased profitability with over 50%. The company currently operates as an assembly network centre working with a number of British and European manufacturers and is heavily involved in research and development activities.

Case 4: Manufacturer of electrical connectors

The company is privately owned and involved in manufacturing of electrical connectors for aerospace electronics and telecommunication equipment. The products are specifically tailored to customers' needs. As a result, the company's structure is entirely team based with the current 45 employees participating in six teams. Each team comprises people with complementary expertise and is assigned to work closely with a particular customer. The ability to work in intra-organisational teams is crucial for company's overall performance.

Case 5: Research and development engineering consultancy

The company offers software simulation packages for new product development and performance measurement testing and was established in 1996. It currently employees 7 full time computer engineers, 4 of whom have prior working experience in large corporations, where they have developed a number of contacts in the software industry across Europe and United States. Over 25 mainly self-employed experts also work on different projects when additional expertise is required.

The present study was carried out using a multi-method approach. The companies selected were initially considered as a focal point for identifying project partnerships. Each company was asked to identify a multidisciplinary partnership in which the particular organisation had played a leading role in terms of resource

commitment and the outcomes of the partnership were highly satisfactory. In order to maintain consistency between cases, the teams were selected according to the following criteria:

- Teams included members with diverse expertise (different functional or subject areas).
- A variety of communication channels were used with electronic communications being the main method throughout the lifespan of the project.
- Teams included members from more than two organisations (or independent experts) worked on the project from different geographical locations.
- Teams working on projects, the outcomes of which were considered by the companies as highly successful in terms of new knowledge creation resulting in highly innovative outcomes.

In order to achieve consistency between cases, the collective knowledge created in each partnership was measured using the Innovation Assessment Questionnaire previously used by Sethi (1995). Further evaluation was carried out using a creativity scale (Andrew and Smith, 1996), which measured the originality of the project outcome (novelty dimension) and its usefulness (appropriateness dimension). The partnerships, which took part in the study, had high scores for both novelty and usefulness.

The identified five multidisciplinary teams were further investigated in-depth using a variety of data collection approaches. The data were analysed using content analysis and a coding scheme procedure (Weber, 1985) in order to illuminate the underlying differences between the partnerships and identify the key factors/processes affecting the teams' abilities to create new collective knowledge.

6. Summary of the research findings

The initially approached five companies showed a trend towards breaking with an old tradition of developing business. A common characteristic is that they currently develop their products or perform their operations relying entirely on partnerships which required implementation of profound changes in the organisational strategy, structure and everyday routines. Two distinctive paths in their developments were identified.

In three of the cases, the businesses were formed around an exciting idea and realised potential of working jointly across business boundaries. The team members which were former university colleagues and computer scientists in one of the cases and in another case professionals with a long standing experience from working for large corporations which felt that they do not really belong there, came together as teams because of their similar educational and professional backgrounds with clear understandings how to exploit the potential of information technologies. As one of the respondents stated: *"our futures depends on opportunities spotters rather than marketers".*

In contrast, the other two businesses went through a long period of organisational and cultural adjustments to find a new way of radical thinking (complete changes of the product/service offered, sharing information / resources, learning to work and trust people which never met before, etc.), either forced by changing trends in the particular industry or by a new generation of the family taking over the business who was no longer excited with the founders' legacy. In both companies there was an understanding among the management team that the changing directions contradicted with some of the traditional working values. In one of the cases the changes have been accomplished by appointment of a new management team and in the other by training and development of the key staff over several years.

However, no significant differences were observed related to the factors triggering the initial formation of the investigated teams in which the above companies had key involvement. A common trend is that an opportunity is spotted or idea arises before the team is formed. The teams were formed in order to accomplish a particular project and, therefore, the team selection in all of the cases reflected on personal skills and knowledge. A similarity amongst teams was that both occupational and contextual knowledge sources were acknowledged and sought out at the teams' formation stage. Initially, when staffing the project teams, the focus was on occupational knowledge. Consistent with past research in product development, these teams were expected to leverage expertise of diverse functions and scientific fields to accomplish challenging development needs.

Clear occupational belonging of team members proved to be an influential factor during teams' initiation and formation. Because of the temporary nature of the projects, team members import to the partnerships their perception and understanding about each other's potential to contribute in terms of having an appropriate occupational knowledge. For example, *"He's electrical engineer"* or *"I'm an experimental scientist"* acted as

shorthand for conveying information about distinct skills, expertise and conceptual insights that someone might bring to bear on a problem. The relationships building at that stage were based on the potential to contribute unique personal knowledge and are highly de-personalised. Team members interviewed stated that *"what others can bring to the project rather than how we feel about working with each other"* are the most important initial selection criteria. Positive expectations of members' valuable occupational knowledge, therefore, motivate participants to take a proactive part in the team, which resulted in strengthening the trustworthy relationships amongst team members and contributed to establishing more active knowledge sharing practices.

At the same time, a clear tendency to access help particular to a specific site, led to considering the locally based or contextual knowledge as a new and distinct source of value for the development teams. In some cases understanding the context in which the product was targeted for use was critical for making appropriate social and cultural decisions regarding its design and implementation. Whenever possible, potential users of the product were intentionally sought to represent that unique viewpoint within the team. On number of occasions contextual knowledge simply entailed knowing who's to contact for further advice or resources in order to accomplish certain objectives.

An interesting relationships were observed between team members with clear occupational and others with contextual knowledge. Although acknowledged, that understanding the context in which the product/consultancy advise was targeted for use was critical for making appropriate social and cultural decisions, the occupational specialists were considered as the *"knowledgeable"* hard core of the teams and to rest was referred as *"social agents"* brought in on ad-hoc basis.

Teams which realised early in the formation stage the importance of continuously combining contextual and occupational knowledge throughout the lifespan of the partnership were more flexible in redirecting the project by recombining knowledge according to external, environmental changes such as changing customer requirements, new competitive offerings, new technological advances, etc. These external changes led to redefinition of roles and responsibilities in the team and introduction of complementary external expertise as required. This caused further changes in the team's patterns of interaction and knowledge base. Therefore, ensuring appropriate mix of expertise throughout the lifespan of the project contributed to the progress of the projects which increased members' confidence in the ability of the team.

The results of the study also confirm that social and personal relationships within a given local (physical) or virtual community were extremely effective in gaining team members 'just-in-time' access to specialist knowledge and practical skills as and when the team needed it. Through such boundary spanning activities, project teams gained access to broader and deeper skills and expertise which helped in addressing specific project issues. Teams' members, for example, regularly pulled in their collocated colleagues for assistance with practical advise or input on decisions, all of which enabled the projects to proceed to the next stage. Seeking assistance from a wider community, however, was more than just seeking additional feedback and task related assistance but also looking for moral support when faced with difficult decisions. Therefore, the intellectual, virtual and co-located communities of which members are part, became an integral part of the thinking and discovery processes and filled knowledge gaps by contributing timely and efficient access to broad expertise, practical assistance and emotional support which were not internally available.

The findings also raise number of questions such as: What is the impact of cross-cultural differences on developing collective knowledge?, What novel theoretical approaches can capture the complexity of such relationships?, How can we and should we separate in our analyses the team members from the organisations they represent and the wider community in order to gain an in-depth insight?, How to transfer the successful experience from one partnership to another?, etc.

A limitation of the reported results is that initially the participating companies rather than the partnerships were approached. The partnerships were identified based on the companies' preferences, which may have affected the validity of the results. Another limitation of this study is that because of the geographical distance of the partners involved not everybody associated with a particular project was approached during the data collection. In that respect the results presented here should be treated as preliminary.

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