FROM HERE TO ETERNITY?: CHALLENGES OF TRANSFERRING SITUATED KNOWLEDGE IN DISPERSED ORGANISATIONS

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This paper extends theoretical and empirical debates on knowledge transfer in geographically dispersed project teams. It draws upon studies of five international, project-based firms. The paper presents quantitative data comparing knowledge sharing practices between dispersed and co-located teams. It shows that contrary to conventional wisdom, their respective practices are similar for many work activities, such as face to face interaction, email and project websites. However dispersed team members use the telephone for all types of knowledge exchange significantly more than co-located teams. The paper then illustrates typical interactions using the differing means and media available to the observed project teams.

Keywords: dispersed teamworking, virtual teamworking, knowledge transfer, co-location

"Everybody's got to be somewhere."

Spike Milligan

1. Introduction

This paper presents new research on knowledge transfer across space. It derives from a study of five organisations doing project-based work in dispersed and co-located teams. The research has two main implications for prior work. Firstly it challenges the early sanguine view on dispersed or virtual teamworking organisation that insisted on the fluid and effortless transfer of knowledge. Second, it extends the more recent and circumspect literature focused on dispersed teamworking practices. It provides quantitative data on the media of choice for work activities constituting different types knowledge (or information) exchange. This shows that dispersed teams are not dissimilar to co-located ones in their communications technology use, but there are some essential and significant differences. The paper complements these findings with qualitative insights on the typical interactions within the teams when using different means of communication.

The paper is structured as follows; the next two sections provide the conceptual background, firstly as regards the Dispersed or Virtual Teamworking Literature (DVTL 1) of the 1990s, and second the more recent literature that emphasises practices in the work of dispersed teams. Following this review of earlier contributions the next section describes the method employed for our study, in particular the survey. Section Five presents the results of the survey showing the similarities and dissimilarities of co-located and dispersed teams. Section Six presents the results of our qualitative interviews and observations of project teams, showing the typical uses of each means of interaction in turn; face to face interaction; telephone communications; email communications; videoconferencing and Extranets. The paper concludes in section Seven.

2. The Dispersed or 'Virtual' Teamworking Literature (DVTL 1)

In the 1990s, advances in information and communications technologies together with increasing globalisation of corporate activity instigated an influential thread of literature arguing for new possibilities for dispersed work. 'Virtual teamworking' enabled by the new technologies was argued to be "a potent response" to the problems of a dispersed workforce (Townsend et al., 1998: 17). Key employees "may be located anywhere [in] the world" (*Ibid*.). The globally distributed organisation was argued to be able to access knowledge workers residing in previously inaccessible remote locations. This sanguine view is exemplified by this quote from Townsend, DeMarie and Hendrickson:

> This new workplace will be unrestrained by geography, time, and organizational
> boundaries; it will be a virtual workplace, where productivity, flexibility, and
> collaboration will reach unprecedented new levels. (*Ibid*.)

One confusing aspect of this literature is a blurring of the distinct concepts of geographical dispersion and network-type organisation structure that often involves outsourcing; both are referred to as 'virtual', and are used interchangeably. Both senses of virtuality apply in many cases, but it is equally possible that a networked organisation may not be especially geographically dispersed. Similarly a highly geographically dispersed organisation may nonetheless be tightly integrated within a corporate structure of control and hierarchy. For the purposes of our study we are primarily interested in the *spatial* meaning of virtuality.

A typically cited distinguishing feature for both senses of virtual organisations is their dependence on information and communications technologies (ICTs) in order to accomplish their tasks (Palmer, 1998; Jackson, 1999). This would appear to be true of any modern work organisation however, but there is in the literature a perception that the capabilities of email, videoconferencing, internet technology and groupware *permit* and *enable* the virtual organisation or team. This argument is pushed even to the extent that dispersion of team members is almost an irrelevance; "Thanks to these new technologies, teams can now be effectively reconstituted from formerly dispersed members." (Townsend et al., 1998: 18). Physical space is seen as something of an anachronism; "Organisations used to be places…Through the use of telephone, fax, electronic mail, computers, video, and other

information technology, people and their organisations…can act as if they are completely connected while remaining far apart" (Morgan, 1993: 5); virtual organizations have "no identifiable physical form…and boundaries defined and limited only by the availability of information technology" (Barnatt, 1995: 82-83).

This strident literature arguing for the revolutionary nature and benefit of virtual teamworking and organisation dominated the late 1990s. Virtual working enabled by ICTs was seen as an effective response to the needs for remote enterprises to have a local presence in global markets, to be flexible and responsive, and to enjoy substantial cost advantages and around-the-clock working (Boutellier et al., 1998; Grimshaw and Kwok, 1998; Gorton and Motwani, 1996). Knowledge transfer specifically received little attention, while the advanced *information* transmission and processing capabilities of the new technologies were stressed. This early Dispersed and Virtual Teamworking Literature (referred to as DVTL 1) has been joined by more recent research examining the extravagant claims for virtual or dispersed work.

3. Recent Research on Dispersed Teamworking Organisation: Focusing on Practice

More recent research on the functioning of dispersed teams and organisations has closely examined their working in practice, and taken a more measured view of their limitations. Much of this research pays greater attention to the transfer and integration of *knowledge*, rather than simply information emphasised by the earlier literature. While the new technologies offer vastly increased information processing power, there is increasing recognition that knowledge by contrast is not easily stored, transferred and switched around networks for the easy access of virtual team members. This strand of literature is influenced by the work on communities of practice (e.g. Lave and Wenger, 1990; Lave, 1991; Brown and Duguid, 1991; 2001), and the organisational theory on *knowing* (e.g. Blackler, 1995; Tsoukas, 1996). These schools of thought stress the embeddedness of knowledge in *practice;* the everyday routines and actions performed by the members of a team to get their work done. Accepting this view entails recognising the importance of the context specificity of the knowledge of a team. Interactions are understood as situated group cognition, and a key part of the situation is the location.

The implication of this line of thinking is that if organisational knowledge is embedded in local practice its transfer to remote co-workers is therefore restrained (Sole and Edmondson, 2002). The practice approach is therefore sensitive to the difficulties of dispersed teamworking and organisation. However it also refocuses attention on the practices that make virtual team activities work, albeit it in a more circumspect way than was thought under DVTL 1. Orlikowski's (2002) study of a global product development team is a prime example. Through inductive qualitative techniques she identifies a repertoire of practices, activities that comprise the practices, and associates these with various senses of knowing. The practices are sharing identity; interacting face to face; aligning effort; learning by doing and supporting participation. Together, Orlikowski argues, these practices comprise a capability in distributed organising. For example, she shows that interacting face to face comprises activities such as gaining trust, respect, credibility, commitment, building and sustaining social capital. These activities constitute 'knowing the players in the game'- the dispersed team members. Other practices constitute other forms of knowing that are critical for virtual working.

Orlivkovski's emphasis on face to face interaction concurs with prior research which has shown that interacting face to face generally solves problems and completes tasks faster than electronic-mediated communication (see DeSanctis and Monge, 1999). Where dispersed teamworking permits face to face interaction, as in the Orlikowski study we might expect more effective results than where it is prohibited. This is also found by Maznevski and Chudoba's (2000) study of three teams within a globally distributed organisation. They show that effective virtual teams generate a rhythm of regular face-to-face interaction incidents, but interspersed with less intensive interactions using other means of communication. Somewhat counter intuitively, they argue that decision processes are organised to fit the temporal sequence, so that functions are modified to accommodate the communications media, rather than the other way around. In a sense, they are saying the medium determines the message.

Maznevski and Chudoba identify a hierarchy of four decision processes that comprise the objectives of interactions: information gathering, problem solving, idea generating and comprehensive decision making. Similarly to Orlikowski they highlight the importance of generating commitment to action, a fifth process that crosses the hierarchy. In effective teams, the higher the level of decision process in this hierarchy the richer the communication medium used. Thus simple information gathering was done by emails, faxes and quick one-

to-one phone calls, while at the other extreme comprehensive decision making was done through 2-day face to face meetings. The less effective team had no such appropriate match between function and medium.

The limitations of virtual teamworking are also explored by Cramton (2001; 2002) who highlights the importance of 'mutual knowledge' in dispersed teams. Through analysis of completely virtual project teams of students, she identifies five types of typical problem rooted in a failure of mutual knowledge between dispersed team members. These are failure to communicate and retain contextual information, unevenly distributed information, difficulty communicating and understanding the salience of information, differences in speed of access to information, and difficulty interpreting the meaning of silence. These problems seem to address information rather than knowledge, yet the strength of this work is its sensitivity to group politics. The study demonstrates how the typical pitfalls of virtual work are implicated with the emergence of hostile coalitions, exacerbated by misunderstandings rooted in their remote location. Cramton also tries to draw out performance implications but the results are puzzling and inconclusive, since high performing student teams showed both high and very low levels of email interaction and coalition behaviour.

In summary, these studies are important contributions towards a more sophisticated understanding of the behaviour and limitations of dispersed teams. Orlikowski inductively shows the key dispersed team practices in the sense of meaning and function and the forms of knowing that they comprise. She stresses the importance of meeting face to face and the use of project management tools and methodologies, but says little about other practical means of interaction. Maznevski and Chudoba's study matches medium of interaction with complexity of function, and argues that a rhythm of interaction is established in effective teams and that objectives and functions are modified to accommodate the media. Their study reveals the typical activities for which telephone, fax and email are used, by comparison with face to face and longer teleconferencing. However it does not include some of the more "advanced" communications technologies, videoconferencing and electronic groupware and Extranets. Cramton's study shows typical failures of virtual teamworking and the effects of group politics, although her teams' interactions are almost entirely through email. It may be that a less restricted choice of means of interaction may have avoided or resolved the problems that she observes.

With the exception of Cramton's cross-university experiment, these are all single organisation studies of dispersed teamworking. They are using primarily systematic qualitative methods. Their contribution is the emphasis on practices, and how the available repertoire of means of interaction may facilitate or restrict the transfer of situated knowledge. They do not explicitly address how dispersed team practices differ from co-located ones, where some of the same practices would be equally in evidence. This seems to us to be particularly so for face to face interaction.

The following section describes the method for our study, which aims to complement and build on this earlier work.

4. Our Study's Method

Our study aims to build upon the received work on practices in dispersed teamworking. The research is being conducted as part of a two year project called 'Managing Knowledge Spaces'. The project is a joint undertaking between the Centre for Research in Innovation Management and Imperial College Business School, and several industrial partners that are all leading international companies. The aim of the research is to study the behaviours associated with dispersed teams in these organisations, and compare these to co-located teams. The organisations are derived from a diverse range of sectors, but our units of analysis were project teams performing comparable 'knowledge work' tasks. By examining pairs of co-located and dispersed teams, the aim was to understand the implications of dispersing a team across space as regards how they share and apply their knowledge. Following this stage of the research we will analyse the performance effects of different spatial team configurations. In addition to the academic contribution the project will produce a diagnostic tool to serve as a useful aid to our partners and other organisations.

As part of the research, we conducted a survey of co-located and dispersed team members within our research partner organisations. The survey was designed through an iterative process. Drawing from the literature, our own prior research and a workshop with our partner organisations, the research team developed a list of different means of interaction available to team members. This list of means of interaction includes a mixture of personal and electronic-mediated forms of communication. Our desire was to contrast the importance of different media for different types of activities.

For each means of communication, respondents were asked to assess the importance on a 1-5 likert scale. The list included: informal face-to-face conversations with individuals inside the team; informal face-to-face conversations with groups of team members; formal team meetings; telephone conversations; teleconferences with other team members; email communications; video conferencing; the use of groupware; and project websites. The research team also developed a list of different work activities, drawn from the existing literature on teamworking and our interactions with our research partners. The list of work activities includes: searching and scanning for new ideas; consulting team members on technical solutions; verification and validation of concepts and ideas; routine information exchange and the resolution of management problems on the project.

The survey was administered to all interviewees prior to a formal face-to-face interview. Respondents were given the opportunity to write-in responses on the survey and were invited to comment on the issues that arose while they were completing the survey. Respondents were promised full confidentiality and all data arising from the survey has been presented to our partner organisations in aggregate form. In our workshops and reports to our partner organisations, we have presented the results of the survey and this has provided an opportunity to gain feedback on them. The reporting of the results has been strongly influenced by the reactions of our subjects to the analysis of the data. In our validation workshops, our partner organisations were asked to indicate whether they felt that the data represented actual practices within their organisation.

All members of the research team were involved in the survey's design, data collection and analysis. At the present time, we have received 41 completed surveys from five different organisations. A modest share of interviewees did not complete the survey and therefore the sample is not a complete representation of all team members' interviewed and observed in our study. The survey responses, however, represent a broad range of opinion from different team members. The pattern of non-response mirrors the sample population. We believe that the survey results reflect the overall views of the interviewees.

5. Results from the Survey of Means of Interaction

A central objective of our research has been to integrate the research findings from interviews, observation, workshops and the survey. In this section, we examine the initial

results of our survey of working practices and means of interaction among co-located and dispersed teams. The survey results are presented both in aggregate and in comparison between co-located and dispersed teams. In this section, we focus on the relationship between means of interaction and different work activities.

Table 1 reports the results for all respondents for all firms. Among our sample, face-to-face communication appears to be important for a variety of work activities. The importance of face-to-face communication is greatest from searching, consultation and verification of ideas and concepts. Respondents indicated that resolving management problems relies heavily on face-to-face interaction. Face-to-face is relatively less important for routine information exchange. Team meetings are most important for verifying concepts, information exchange and resolving management problems. The results for the electronic means of interaction are mixed. Email is of greatest importance for information exchange and telephone conversations with team members are important for consultation and verification. Video conferencing and the use of groupware were found to relatively unimportant for all different management activities, reflecting the widespread malaise toward these technologies among our interviewees in general. Project websites were somewhat important for information exchange, but played little role in searching, consulting and verification. Overall, the results suggest that face-to-face communication remains central to most of the sample's work activities, supplemented by email and telephone conversations of information exchange and consultation.

INSERT TABLE 1 AROUND HERE

Table 2 delves more deeply into the survey results and compares the attitudes of members of co-located and dispersed team members. The analysis is preliminary. It is based on a comparison of means between the two populations using a Mann-Whitney non-parametric estimate. A Mann-Whitney estimate was selected because of the small size of the co-located sample. Table 2 reports only the significant differences between the two populations, reporting the Z-statistic and the significance levels.

INSERT TABLE 2 AROUND HERE

Overall, the results suggest that there is much in common between dispersed and co-located teams in the importance of different means of interaction for different work activities. Both dispersed and co-located teams rely heavily on face-to-face communication. In general and as expected, co-located teams rely more on the personal interactions than dispersed teams. However the differences between the two groups for the importance of face-to-face are not significant, suggesting that differences between the two groups in the need for face-to-face interaction is less great than is often assumed. The major difference between the two groups was in the use of the telephone as a means of interaction, including both one-on-one telephone conversations with team members and teleconferencing. Dispersed teams were highly reliant on telephone conversations for all different types of work activities, especially for searching, consulting and verifying their ideas and concepts. Dispersed teams used more video conferencing for searching and scanning for new ideas. However and somewhat unexpected, the importance of email was similar across the two groups for each work activity, except that co-located team members appeared to find email more important for routine information exchange. There was little difference between the two groups in the importance of project websites.

In summary, although the survey results are preliminary and modest in number, they show that face-to-face communication remains an essential tool for many different work tasks in both co-located and dispersed teams. The importance of telephone conversations is greater for dispersed teams, yet email is important for both dispersed and co-located team members. The results suggest that dispersed and co-located team members rely on a range of tools for developing solutions, solving problems and exchanging information, shifting back and forth between electronic and face-to-face communication.

The survey results complement and extend the prior qualitative studies in the literature on practices and the means of interaction to enact them. However our study also involved qualitative methods for a deeper understanding of the interaction types referred to in the survey. For example while we confirm the importance of face to face interaction, the typical contexts of these interactions could only be revealed by semi-structured interviewing of practitioners within our partner firms, as well as observation in the field. Thus far in our fieldwork we have conducted 85 such interviews lasting between one and two hours each. For some of the smaller co-located teams we were able to interview virtually all team members. For the larger and dispersed organisations we selected interviewees so as to take a

"slice" through the team so that hierarchical levels and differing functions were represented. We travelled to the various sites of the dispersed teams to interview people *in situ*.

Our observation work involved the researcher sitting in the project team work space, in their face to face and videoconferencing project meetings and making observatory notes on the nature of interactions and movements. There were also opportunities for analysis of project websites and electronic communications such as extranet dialogues and discussions. These observations typically lasted from one week to three weeks for each team. The following sections offer some illustrations and insights from our qualitative research as to how the various means of interaction were used, for what purposes, and with what effects.

6. Means of Interaction and Typical Activities of their Use

The following section parts address each means of interaction and provide illustrations from our interviews and observation data on the typical functions of the interaction. We address face to face interactions, telephone calls, email, videoconferencing and Extranets.

Face to Face (F2F) Interactions

Respondents almost unanimously confirmed the well-established finding that meeting F2F early in a project was important to its eventual success. The opportunity to "eyeball" people, as well as to socialise, eat and drink together was important to many team members. Of more interest were the specific work activities undertaken in such F2F meetings that determine subsequent performance. Several respondents pointed to activities involving *architectural* and *systems design* thinking, one program manager said:

> I would say that that's true [if not for early co-located meetings the project would not have been so successful] because we're not in execution mode for the most part, solution, architecture and integration and understanding the relationships within the projects, until you get that cohesive you don't really have a group of people going in one direction. Before that was happening… was everybody would have their own version of where we were all going, some consistent, some inconsistent, some areas

of commonality, some definite areas of 'that's not what I think you're doing', that's what I thought I'm supposed to do', so those were beneficial.

A complex design task early in a project benefits from co-located F2F meetings, this same manager put it in quantitative terms; if he could have brought together all the team members for a 2 week period at the beginning of the project, it would have saved 6-7 weeks over the whole term. This is a powerful statement of the costs of restricting travel and F2F opportunities. Other interviewees also confirmed the importance of F2F contact for complex conceptual development and architectural thinking; the "big items" such as identifying core activities. Other tools and technologies of interaction were inadequate for such group task interactions:

> Those face to face meetings are invaluable when you get on a whiteboard, you can't do it on the phone, even with videoconference, you just can't, you get on a whiteboard and you start 'No, this is what I mean by part of a description and an integration of a hierarchy', its like, how do you even explain that on the phone, until somebody gets up there and starts drawing dashes and the lines, things like that?"

Another area of F2F activity that people identified was the lobbying and politicking aspects of program management, particularly for the process of gaining acceptance and commitment. This echoes Orlikowski and Maznevski and Chudoba's work, but the finding that architectural and systems level thinking and working suffers without F2F meeting provides new insight as to exactly why it is important to meet early in a project when such conceptual planning occurs. To have the key players physically present to contribute to drawing diagrams and other visual constructs appears critical to building an agreed program structure. These act as boundary objects (Star, 1992; Brown and Duguid, 2001; Yakura, 2002) between the dispersed participants of a project and symbolise their agreement. The research suggests that such boundary objects when virtually constructed are less potent.

In a consulting engineering project the types of activity associated with face-to-face communication also revolved around decision-making, conceptualisation, and visualisation. As an example of conceptualising activities, a temporarily co-located core project team was primarily focusing on developing and evaluating different design options. The core team

consisted of different discipline specialists providing civil, electrical, and mechanical engineering input. The consideration of alternative design concepts involved drawing upon and integrating these different knowledge domains. This was achieved through recursive, largely informal and unplanned face-to-face interactions between members of the team, who were sitting no more than a few metres apart. Close co-location was also thought by project participants to be useful in ensuring that different people had at least a background awareness of different aspects of the scheme, meaning that discussions could be held without the time-consuming need to provide large amounts of contextual information. This could be accomplished almost accidentally simply by being in an environment where it was easy to pick up on the surrounding talk. As an electrical engineer explained, "it's all those small but very important pieces of information that can only come to light when you're talking here informally, or you hear a comment by somebody and … it's something which is very difficult to convey through something like an Extranet".

These design evaluation activities relied heavily on visual communication which, although not impossible, team members considered to be more problematic at a distance. Sketches, design drawings, and photographs often provided a focal point around which discussions revolved. In addition, the ability to visualise the construction, a Hydro-Electric Power scheme, was thought to be enormously helpful in developing and evaluating design options. This could only be partially achieved through consulting the large volume of design drawings, plans, specifications, and photographs supplied by the client. For such construction projects the team members felt the need to experience the space where the facility was to be. Consequently, efforts were made to ensure that all key members of the project team visited the site at least once. According to one of the civil engineers, it allowed him to get "a good feel for the area … and then you see one photograph and you can recall things … I feel I can discuss it with the site more, whereas if you're just given small pieces of it … it's giving a small bit of the picture until you go and view it and see the whole picture yourself".

This example illustrates a sense of 'pull' that dispersed team members feel towards certain other sites. One practitioner used the analogy of a perceived *epicentre* of virtual projects and programs. Clearly in a construction project the epicentre as a focus of attention and activity gravitates towards the site of the construction, but the location of the epicentre may be fluid through the course of time. This sense of spatial centrality is sometimes observed as a centre-

periphery type relationship in the virtual teams we studied. In one case this was a source of frustration for those peripheral sites that were disadvantaged by their distance from the corporate centre in another country, and had no travel budget to mitigate their isolation. One program manager described:

> [In the centre] You're part of this endless round of corridor conversations, which is great and probably gives a lot of energy…but it's a completely useless way of working. If you're not part of that corridor conversation, if you're 6000 miles away and 8 hours out of synch, you're completely hosed.

For such peripheral sites the importance of boundary objects such as project plans and road maps are elevated, and they rely fastidiously on documenting decisions agreed through teleconferencing calls. These program management devices become tools of political influence against the unauthorised but informal domination by the centre. Such political dynamics are important factors in the fluidity of knowledge transfer in dispersed teams that are sometimes neglected in the literature, notwithstanding Cramton. At times the literature is quite mechanistic in its recommending functional practices and techniques, while underestimating the political pressures that may override such good-sense practices.

The interviews and observation data concur with the survey that face to face interaction is valued and widely practised in dispersed teams. It should however be noted that one respondent was entirely comfortable with virtual teamworking and given a telephone and a workstation, claimed working on the moon would not be a problem! There was a general awareness that travel and F2F contact do not always justify the associated costs and inconvenience. However there was a convergence of opinion about those activities that do derive benefit from it. There was also a general view that if not for early F2F opportunities projects would have made slower progress and produced poorer outcomes.

Telephone Communications

Where F2F meetings were prohibited by cost or logistics, teleconference calls were seen as the "meat and drink" of dispersed teamworking, the next best thing to F2F. Routine conference calls were a means of ensuring alignment across sites, and discouraging

"breakaway" behaviour. In one program managers observed this type of localisation and instituted routine daily conference calls with deliberately interdependent tasks. In this way some cross-site teamwork was necessary to accomplish tasks, although the powerful local affiliations did not disappear. One interesting indication of this is the use of the 'mute' button in conference calls. The mute button was often used to allow local team members collected in the conference room to agree a group response, while excluding their remote colleagues from the discussion. While this behaviour is generally understood and accepted as standard practice, people are sensitive to when it is happening and feel the group experience is somewhat undermined. It clearly illustrates the power of locality in team decision-making, providing further evidence of situated knowledge and the bias towards local transactive memory, or knowledge of what the others in the team know (Sole and Edmondson, 2002; Wegner, 1987; Moreland, 1999).

Some con calls in our teams could last up to four hours and could involve up to 20 people, and many find them tiring and frustrating. They can become "a rock moving exercise". Concentration can wander, especially if people are trying to accomplish other tasks simultaneously if they are at their desks.

One manager put it well:

> I do think it's hard to stay plugged-in. It's kind of draining, you know. It's hard on the team to be on a conference call for 2 hours. It is like hell…Yeah, it is a long time to stay on the phone, I know because I'm facilitating it.

Individual calls are used for validation and consulting colleagues on specific problems. They are useful for a "personal touch", such as following up with someone following a con call or email to clarify "This is what I understood". This is also consistent with the survey findings that dispersed team members use the telephone significantly more than their co-located equivalents for validation and verification tasks, as well as consulting colleagues on technical problems. Interviews showed that individual calls are also used for building good will and morale, for example, asking about people's personal interests.

All in all, this belies the fluid, lightsome image of virtual teamworking from the early literature where information is effortlessly transmitted across the globe through high-tech

connections. Rather, the reality of dispersed teamworking appears as often gruelling, sustained teleworking. Formal teleconferencing meetings are controlled and concentrated so as to discourage localised fragmentation. While in addition, iterative validation and verification phone calls are frequently required. Dispersed teamworking tasks are not easily and instantly accomplished but require substantive, sustained effort.

Email Communications

Interviews confirmed what the survey results showed; that email was a primary means of exchange of routine information. It was a somewhat more surprising result that co-located used email to interact with their colleagues about as much as the dispersed ones. This partially reflects the fact that truly hermetically-sealed, co-located teams are extremely rare. Any team will need to access external sources of knowledge whether in the form of clients, company colleagues in other departments, personal contacts through education or professional networks. A study such as this pairing co-located and dispersed teams is to some extent interpreting and positioning the units of analysis on a continuum. However, our interviews and observations have nonetheless confirmed that people working within sight and easy walking distance of each other's workspaces will routinely email each other rather than other forms of contact. This is because the asynchrony and precision of email communication is effective and unobtrusive for routine type project information. It is the function of the interaction that clinches this choice of medium, rather than the spatial proximity.

In some teams the information function of email overlapped with project websites and simple GroupWare applications such as shared folders. For most email was identified by participants in as the dominant mode of communication between team members, even between clusters of project personnel with adjacent desks. For example, for a water treatment works project although email was ubiquitous throughout its duration, this mode of communication was used most extensively during the detailed design and construction phases when the number of face-to-face meetings between different parts of the team decreased. The types of activity associated with email mainly involved relatively straightforward information exchanges without that many iterations. The instrumentation, control, and automation engineer described his typical use of email as follows: "I prepare specifications. So I write a specification for something. This is how the contractor is going to do it, the things he's got to comply with. That starts off as a draft. And that draft … well it will have some comment

within the office, perhaps. But once it reaches that stage it will then be sent to [the contractor] because they're the people who're going to have to implement it. And we'll send it to them for comment, and we'll get it back again … annotated in some way … So I get comments back again in an email. And I go back and open up the documents, see what the hell's he's talking about, oh yeah, right I've missed out … spelled something wrong, or whatever, and I correct it. So that's a perfectly straightforward use of the medium. Which is fine".

However, several limitations of email as a medium were recognised by project participants. In some cases this meant that other modes of communication were judged to be more appropriate for certain activities. For example, the relatively straightforward flow of design information was disrupted mid-way through the project because initial results from pilot testing indicated the need for changes to the process design, which had potentially serious implications for the scheme. The contractor was particularly concerned about the impact on costs and a series of emergency meetings was convened to discuss the issue. In other cases, email continued to be used even though it might not have been appropriate. This type of function-medium mismatch was identified by Maznevski and Chudoba as a distinguishing trait of ineffective virtual teams. Indeed, this appeared to be a general point of concern for senior managers to the extent that the chief executive had issued a group wide memo about the appropriate use of email, urging employees to "remember communication takes many forms so use the one most appropriate to each situation. Do not let the computer screen replace human interaction".

Other issues relating to email concerned dilemmas about who to include and exclude when distributing emails and points of style and etiquette. Several project members admitted that they often found it difficult to know how widely to distribute emails. On the one hand, there was the danger of disseminating too widely to include people for whom the content was only of peripheral relevance, and, on the other, of excluding people for whom the information might be useful or even critical. The nature of email as a technology means that it is almost as easy to send to many people as to just one. As one lead design engineer put it, "that's a bit of a bane of the communications revolution, the number of emails that do fly around and how easy it is to copy everybody in". The inverse problem is when dissemination does not occur widely enough. As one of the electrical engineers explained, "if you're not copied in on the emails it could be a week before you find out … that decision's been made, this is what we're

doing, ah, I need to change my ideas on that one. It doesn't happen that often, but on the odd occasion …sometimes people get left out of the loop". The style adopted for emails was also a point of contention. According to one project member, "I'm not at all happy with the way we use emails. I think it's a pretty sloppy method of communication. And it's pretty difficult to figure out, very often, just what the sense or the intentions or the meanings of it all is".

Videoconferencing

Opinion was divided over videoconferencing. Many respondents found that videoconferencing did not add much value over telephone calls. Most found it was technically clumsy, inconvenient to set up, and sometimes distracting, if for example, taking notes. This was not a view shared by all however, some - particularly the more senior-managers found video was a welcome substitute for F2F meetings and definitely added value. It enabled some facial expression communication, and facilitated meeting management more than teleconferencing. If people are not paying attention, "you can reach out and smack 'em" explained one program manager.

In the Hydro Electric Power (HEP) project videoconferencing was used for communications between the core project team and people whose input, while not insignificant, was not thought sufficient to justify the time or expense of a face-to-face meeting. In particular, there were a number of aspects of the scheme, which required specialist input from discipline experts distributed around the organisation. These contributions were partly provided through videoconferences, although this happened in conjunction with other modes of communication such as email and telephone conversations. Indeed, the interactions tended to be structured in such a way that a video conference would only be arranged after there had already been an extended discussion and clarification of the required input via email and telephone. As one of the discipline experts explained, the purpose of the video conferences was less for substantive discussions of technical matters or detailed decision-making and more for ensuring agreement around key issues and "decide a way forward for difficult issues". She went on to comment that, as part of the etiquette for conducting videoconferences, participants were expected "to prepare groundwork first … rather than sometimes you could be in the dangerous situation you don't really move forward but keep discussing". The result was that video conferencing sessions were kept relatively short and focused, lasting only between ten and thirty minutes.

Opinions, however, varied as to how effective these sessions were, particularly in how far they were able to build robust relationships across different parts of the project team. For the discipline experts, who were more peripheral to the project and had no face-to-face contact with other members of the team, video conferencing was regarded as vastly superior to conducting interactions purely through telephone and email. For one of the experts, participation in videoconferences meant that subsequent communication through other media was easier: "I think it is quite helpful, particularly for later telephone discussions and you can really picture… the person..."

Others were unconvinced. The project manager, for example, was doubtful as to what extent video conferencing without any face-to-face meetings allowed a close relationship to be established with the technical specialists. This was thought to have led to a series of misunderstandings about what was required from the specialists. In one case, one of the discipline experts, unable to provide a definitive response, was unwilling to put her recommendations in writing. The mechanical engineer in the core team interpreted this reticence as due to a lack of confidence that her answer would not have negative consequences. He suggested that this lack of confidence could have been more easily overcome if the expert had not been remote to the project, both in terms of physical distance and level of involvement.

Websites, GroupWare and Extranets

Project websites, rather like email were seen as useful for public relations, and practices like status reporting, but are "a third line of defence" in a communications strategy. One manager saw the website as a rather static and passive medium:

> "You need to be out there talking to stakeholders, engage them in the process, have the discussions, show them the new processes, the new systems, ask them their opinion. You can't do any of that with a website…I think the website's neat but I haven't had any stakeholders come in and say 'Geez, I like your website, it's very useful today', not one, and I've got hundreds of them."

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We did not find that teams were using the more sophisticated functions of GroupWare beyond shared team folders with group notice type information. The general feeling was that the technology was not quite good enough as yet, and many had experimented with some GroupWare products previously. There appeared to be an unfulfilled need for example for simultaneous and remote document co-editing, as people were frustrated with the limitations of sending email attachments back and forth, while on a conference call, and getting confused with different versions of documents and similar problems.

Extranets incorporating participants outside the team however were used intensively. The HEP project made extensive use of an Extranet system to which the client had extensive, if incomplete, access. This system had only recently been widely adopted by the organisation, following enthusiastic support from some segments of senior management. As a multi-purpose technology, Extranets have the potential to be used in a variety of ways. In this instance, the functionality of the system provided both for more active communication through email and discussion threads, as well as more passive information sharing, document storage, and retrieval. The key issue for project management concerned how much access to the Extranet to permit the client. As the project manager described it, this was a gradual process whereby elements of the Extranet were progressively opened up to the client as confidence in the relationship developed. He explained the situation as follows: "I think because we now know more how they operate and we know that they have got a lot of good information, they're not just… we feel comfortable going to them and asking them. There's obviously an initial perception they'll think we don't have a clue. But they realise it's a pretty unique thing that's going on here as well, so they're more than willing to contribute". Crucially, this growing understanding was not based solely on interactions within the confines of the Extranet, but on regular face-to-face meetings and almost daily telephone conversations.

However, not all members of the project team were entirely comfortable with using the Extranet. As one electrical engineer admitted, "I was quite reluctant to post what I was doing on the Extranet because I thought, you know, if this is inaccurate or it's wrong, [the client] are going to see this and think who are these jokers on the project". In addition to the public character of the medium, this reticence was exacerbated by the fact that all documentation, correspondence, and discussions were archived according to quality management procedures and, once posted, could not be subsequently amended. As an indication of the concern that

some people had with using the system, the discussion forum was not used as extensively as the supporters on the project of the Extranet had hoped. Nearly 30% of items in the discussions folder were 'orphan' items for which no replies were posted. This does not necessarily mean that they received no response, but rather that replies were redirected through other channels.

Another project team, working on water treatment also used an Extranet, but it assumed a more limited form compared to the first application of the system. In this case it was used solely as a passive document store without using any of the communication or discussion functionality. It was also a largely duplicate and retrospective system. While it was the formal route through which drawings and specifications should be issued to the client, it was often by-passed by people sending documents as email attachments and only later uploading them to the Extranet. There was also some concern about the degree of client involvement in responding to documents posted on the Extranet. This could potentially have led to disputes later in the project since the failure of the client to respond to information on the Extranet was, perhaps dangerously, interpreted as implying acceptance. As the lead design engineer explained,

> We issue them in email format to [the contractor], then we post it on [the Extranet] and people at [the client] who are supposed to get notified get notified by [the system] that it's on there. We just put it on [the Extranet] and if we don't hear anything back, that's it … We never hear anything back … From our point of view it just means that we just get on and agree between ourselves and [the contractor] what we're doing and we're getting on and building it. Doubtless some things [the client] will come back eventually and say we didn't want that, and we'll just say, well, it was on [the Extranet], you should have told us.

These experiments with extranet technology show that it is used primarily to extend routine information exchange with privileged parties outside the project team. In none of the cases do Extranets appear a core medium of knowledge transfer in dispersed teamworking.

7. Conclusions

Our research results and analysis have implications for theory on dispersed teamworking organisation in two ways. Firstly we have shown that the 1990s literature insisting that advances in ICTs mean that space is essentially no longer a constraint on teamworking was premature in its assessment. Knowledge transfer in dispersed teams is not an effortless integration of global diversity transmitted through digital networks, but involves often arduous, recursive work patterns with regular breakdowns in knowledge exchange.

Our survey data showed that dispersed teams do not differ greatly from co-located ones in their use of face to face interaction, email and project websites. Both modes of working involve the use of a variety of different communications media. Yet the telephone as a medium is used significantly more by dispersed team members for all types of knowledge exchange. In particular, dispersed teams' ways of validating and verifying ideas and concepts differed from their co-located colleagues. In project teams that were denied the opportunity to meet face to face, extended teleconferencing was the primary means of knowledge-intensive teamwork. Yet this frequently required follow-up calls for verification and validation. Dynamics within the teams revolved around localised coalitions, restraining the potential for remote transfer.

Secondly, our results extend the literature on practices in dispersed teamworking organisations. Our study was conducted throughout pairs of teams in five organisations and included the collection of quantitative survey data as well as qualitative interviewing and observation. We confirm the same types of activities as consistent with Orlikowski (2002) and Maznevski and Chudoba (2000) and using survey data match these with means of interaction, as described above. A consistent example is the importance of meeting face to face early in a project with benefits for trust and commitment. However we also uncovered the importance of such face to face meetings for architectural and systems level design thinking and working.

For the project teams we studied the opportunity to work in the same space, drawing diagrams and charts, whiteboarding and visualising the forthcoming program was of great benefit for these activities that typically need to occur early in a project. Having experimented with the software solutions attempting to substitute for this type of co-located

work, our interviewees nevertheless found them to be ineffective by comparison to being there. Our study also is distinguished by the range of media available to the practitioners who are working in leading, knowledge-based international corporations. In spite of this we found limited use and enthusiasm for videoconferencing and GroupWare solutions. Time will tell if this is a restriction of the current state of the art, or something more intrinsic about the transfer of knowledge between people.

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Table 1. Importance of different means of interaction for different work activities (n=41)

Means of interaction	Searching and scanning for new ideas and design concepts	Consulting team members on solutions to technical problems	Verifying and validating information, concepts and ideas with colleagues	Routine information exchange	Resolving management problems on the project
Informal face-to-face conversations with individuals working in your team	4.2	4.3	4.0	3.6	3.9
Informal face-to-face conversations with groups of team members	4.0	3.9	3.7	3.3	3.5
Formal team meetings	3.3	3.1	3.6	3.8	3.8
Telephone conversations with team members	3.2	3.6	3.4	3.3	3.0
Teleconferencing with team members	2.8	3.0	2.8	2.7	2.9
Email communications with team members	3.2	3.7	3.9	4.4	3.4
Video conferencing with team members	2.1	2.0	2.1	1.8	2.0
Use of groupware	2.2	2.2	2.5	2.5	2.2
Project website	2.2	2.4	2.4	3.2	2.1

Table 2. Differences between colocated and dispersed teams for the importance of different means of interaction for different work activities (Dis=29, Co=12)

Means of interaction	Searching and scanning for new ideas and design concepts			Consulting team members on solutions to technical problems			Verifying and validating information, concepts and ideas with colleagues			Routine information exchange			Resolving management problems on the project		
	Dispersed	Colocated	Mann-Whitney	Dispersed	Colocated	Mann-Whitney	Dispersed	Colocated	Mann-Whitney	Dispersed	Colocated	Mann-Whitney	Dispersed	Colocated	Mann-Whitney
Informal face-to-face conversations with individuals working in your team	4.1	4.3	--	4.2	4.7	--	3.8	4.5	-1.9*	3.5	3.8	--	3.8	4.3	--
Informal face-to-face conversations with groups of team members	4.1	3.9	--	3.9	4.0	--	3.6	3.8	--	3.1	3.8	--	3.3	3.8	--
Formal team meetings	3.4	3.1	--	3.0	3.5	--	3.5	3.8	--	3.5	4.5	-2.1**	3.5	4.3	-1.7*
Telephone conversations with team members	3.4	2.7	--	4.0	2.6	-2.6***	3.8	2.6	-2.1**	3.5	2.7	--	3.2	2.5	--
Teleconferencing with team members	3.0	2.2	-1.6*	3.2	2.3	-1.8*	3.1	2.3	-1.8*	2.8	2.3	--	3.0	2.5	--
Email communications with team members	3.3	3.0	--	3.7	3.6	--	4.0	3.6	--	4.4	4.3	--	3.3	3.4	--
Video conferencing with team members	2.2	1.5	-1.7*	2.2	1.5	--	2.3	1.5	-1.9*	2.0	1.5	--	2.0	1.8	--
Use of groupware	2.2	2.0	--	2.3	1.9	--	2.5	2.4	--	2.3	3.1	-1.7*	2.0	2.6	--
Project website	2.2	2.3	--	2.3	2.6	--	2.4	2.4	--	3.0	3.5	--	1.9	2.5	--

*** significant at > .01, ** significant at >.05, * significant at >.10.