DEVELOPING WITHIN-COMPANY INFORMATION AND COMMUNICATION TECHNOLOGIES (ICT) INNOVATION DIFFUSION NETWORKS: A STUDY OF THREE AUSTRALIAN MAJOR CONTRACTORS

Vachara Peansupap[1], Derek H. T. Walker, Peter W. Goldsmith, and Andrew Wilson

Cooperative Research Centre in Construction Innovation, RMIT University, Faculty of Business, Melbourne, Australia

The innovation diffusion and knowledge management literature strongly supports the importance of communities of practice (COP) for enabling knowledge about how to use and adopt innovation initiatives. One of the most powerful tools for innovation diffusion is word-of-mouth wisdom from committed individuals who mentor and support each other. Close proximity for face-to-face interaction is highly effective, however, many organizations are geographically dispersed with projects being virtual linked sub-organizations using ICT to communicate. ICT has also introduced a useful facilitating technology for developing knowledge networks. This paper presents findings from a research program concentrating on ICT innovation diffusion in the Australian construction industry. One way in which ICT diffusion is taking place was found to be through within-company communities of practice. We undertook in-depth unstructured interviews with three of the major 10 to 15 contractors in Australia to discuss their ICT diffusion strategies. We discovered that in all three cases, within-company networked communities of practice was a central strategy. Further, effective diffusion of ICT groupware tools can be critical in developing COP where they are geographically dispersed.

Keywords: communities of practice, ICT diffusion, innovation, technology transfer.

INTRODUCTION

Innovation is one of essential attributes that drive competitiveness in the construction industry (Slaughter 1998, 2000) so an ability to effectively diffuse ICT innovation throughout organizations is pivotal for achieving its useful deployment. It provides the capacity for delivering two types of benefit: process improvement and product development. Process innovation is focused on the '*how to'* capacity that leads to improve or change traditional work processes by introducing cleverer or more effective ways to do things—this in turn can lead to construction management process productivity improvements. Product innovation is focussed upon developing new products in response to market forces (Meyers, Sivakumar and Nakata 1999).

Managing construction projects consists of planning, coordinating and controlling many work processes that span different stages or phases involving many different participants, each often utilizing different information and communication exchange systems. To reduce problems in the construction process, it is essential to provide clear construction information among project participants. Much of the paper-based

[1] vachara.peansupap@rmit.edu.au

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information exchange process during the construction phase involve duplication, continual translation and transcription from one medium or form to another, as well as loss of information (Duyshart 1997). Furthermore the benefits to using an integrated electronic form of communication exchange include many tangible savings such as cost and time as well as many potential intangible savings such as improved and more effective service delivery (Duyshart *et al.* 2003). ICT innovation is therefore a major potential innovation improvement that can deliver real benefits to the construction industry and its participants.

ICT has not only been used to decrease the integration problems but also it can be used as an effective way for experts to share knowledge and to jointly solve problems. For instance, the BP virtual office is one example where complex problems were solved using the expertise of a global network of experts linked virtually (Prokesch 1997). Even using e-mail, which has been previously argued to be information poor due to being context-minimalist, has been shown to be more effective as a tool for low-level knowledge than expected when used by a case study of a knowledge-intensive firm of people familiar with it (Robertson, Sørensen and Swan 2001).

Discussion in this paper is focussed upon explaining the roles of communities of practice (COP) that support the diffusion of innovation within construction organizations. The literature argues that the COP concept has an essential role in knowledge-sharing and in turn can develop a more knowledge-productive culture of learning in construction management organizations (Wenger 1999, Von Krough, Ichijo and Takeuchi 2000, Wenger and Snyder 2000). The role of COP in case study examples from three major Australian construction contractors is presented in this paper. The study concentrates on how these firms diffused ICT applications.

The remainder of this paper is structured as follows: underpinning theoretical concepts are briefly discussed; the research methodology is then presented, followed by a brief description of the three case study organizations and presentation of findings relating to the human infrastructure elements supporting ICT application diffusion. A discussion of findings is then presented and this is followed by conclusions.

THEORY UNDERPINNING THE RESEARCH PROJECT

Much has been written on the need for firms to develop core competencies (Prahalad and Hamel 1990) that provide sustainable competitive advantage either from cost or product/service differentiation (Porter 1990). ICT innovation can be argued to support both a cost competitive advantage (through management efficiency reducing wasted management and administrative energy) as well as providing sophisticated clients with service level improvements that deliver a distinctive and differentiated qualitative competitive advantage. Many firms develop their own competitive advantage through initiating innovation. This can be achieved and may be optimized by effective ICT diffusion occurring at both the individual and organizational levels.

At the organizational level, diffusion of innovation depends on how well organizations can absorb external sources of innovation as well as develop their internal capacity through trial and error experimentation and piloting, research and development and supporting learning systems (Cohen and Levinthal 1990). Absorptive capacity is one of the essential factors that sustain innovation and its diffusion through building up an experience and knowledge base that can be drawn upon when needed to develop or diffuse innovation. This infrastructure capacity helps provide not only the technical and knowledge enablers of innovation and its diffusion, but also can be used to help to

build an organic organization, often unofficial, that utilizes the external and internal sources of knowledge to enhance the internal innovative process or product. Due to the individual features of an organization's business processes, the adoption of external innovation needs to be modified to suit its specific business objective.

At the individual level, innovation diffusion depends upon information or knowledge gatekeepers who help transfer innovative knowledge from external and internal sources to the internal unit of organization. These gatekeepers interpret or transform knowledge into simple language to fit the environmental context of known target groups (Rogers 1995). Diffusion could not be achieved if the individuals within an organization unit do not adopt and diffuse innovation to others.

At the group level, people naturally tend to form knowledge networks to share and re-frame knowledge that they routinely or occasionally use. History provides many such examples of learning communities. The trades and guilds of Europe since medieval times, for example, and more recent cases in point are documented in many organizations. One is the Daimler Chrysler Corporation where groups of people clustered around a particular skill to form 'tech clubs' (Wenger, Mcdermott and Snyder 2002). The power of people forming small groups to learn from each other has triggered a great deal of interest and led to the concept of communities of practice (COP). Lave and Wenger (1991) first introduced this term when studying forms of apprenticeship and social groups as disparate as Yucatec midwifes from Central America, tailor apprentices in West Africa and apprentice butchers in the USA. They studied the way in which these communities shared not only knowledge but also the culture of access to knowledge and the way in which it was used to diffuse complex tacit knowledge. A COP, shares knowledge and skills and sustains its members through obligation to exchange knowledge, providing access and accessibility to shared insights and knowledge about the practice of work.

An ICT diffusion study of 117 people from three large Australian construction organizations reveals 11 broad factors affecting ICT diffusion. These 11 factors were grouped into four clusters of influencing characteristics: management, individual, technology, and environment. ICT diffusion is impacted by management, individual and technology characteristics that affect each other. All these are nurtured or inhibited by organizational culture environmental characteristics (Peansupap *et al.* 2003). One of the more interesting findings from this ICT innovation diffusion study was that people-support, in terms of COP, was an evident element of the four clusters of characteristics. Thus human capital infrastructure appeared to provide a pivotal role supporting ICT innovation diffusion.

CASE STUDY METHOD

The research method was classified as a qualitative research approach (Yin 1994). A semi-structured interview approach was used to collect data from ICT strategists and professional users in the three large Australian constructors at several organizational levels. Interviewees were nominated by key contact people within the IT department who understood the research aims. They were asked to identify ICT users already using ICT in their work so that a better understanding of how these organizations approached ICT diffusion can be found. Thus the sample is not a random sample but a purposeful one drawn from ICT professional users, in major construction companies that principally operate in Australia but also do so as global construction contractors.

Table 1: Categories of interviewee in the three case studies

Interviewee	Case study		
	CSA	**CSB**	**CSC**
IT strategist	1	1	1
Implementer (L1)	1	1	1
Project/Engineering manager (L2)	4	1	1
Site engineer (L3)	1	3	2
Foreman (L4)	1	1	1
Total	8	7	6

The focus of the study was on the organization and the way that it implements ICT diffusion of a groupware ICT diffusion initiative. The research question is directed at understanding how and why observed behaviours took place in diffusing an ICT groupware initiative. It concentrated upon the 'latest wave' of ICT innovation facing major construction contractors and the aim was to gain a better insight into how several of the major global players in this industry sector approach ICT innovation. It was anticipated that the study would allow, through comparing and contrasting the organizations applied to ICT diffusion, better business practices to be identified and the deeper mechanisms underpinning these to be unearthed and understood. While lessons learned may be offered for general acceptance or adaptation, the results are not intended to be seen as a general factual status (audit) either within the organizations concerned or as being representative of all the top tier contractors under study. The sample used is too small to generalize from, but it does enable findings to be used to shed light on ICT diffusion best business practice.

RESEARCH FINDINGS

Table 1, interviewees can be grouped into five levels: IT strategists (senior level management champion and initiative driver) implementers (given the task of encouraging diffusion of the ICT groupware initiative), project managers (responsible for construction teams on projects using this technology), site engineers, and site foremen (both direct users of the technology in coordinating the physical and administrative work being undertaken on-site). The reason for this approach is to gain understanding the factors influencing ICT diffusion from multiple perspectives

Case Study A (CSA)

CSA is a large construction contractor with well over AUD$ 1 billion in annual global turnover. The chief executive officer of CSA established an IT quality assurance strategy vision in 1996. He envisioned IT assisting integration of construction information within CSA. From this vision, the group of regional managers and quality assurance managers had meetings to discuss and explore ICT that could be used for effective communication and coordination between project members within CSA. During the development period, IT staff in CSA worked closely with managers, key end users and champions who have an experience on construction work processes.

The development of the ICT application was based on a software package that provides the basic communication functions for general business needs. Traditionally, most construction information transfer relies on paper-based systems so the software package required design and customization of user-interfaces to suit the traditional construction approach. The ICT application had been customized to be compatible with organizational forms and work processes and this encouraged users to familiarize themselves with entering information using ICT instead of paper. The modules of ICT

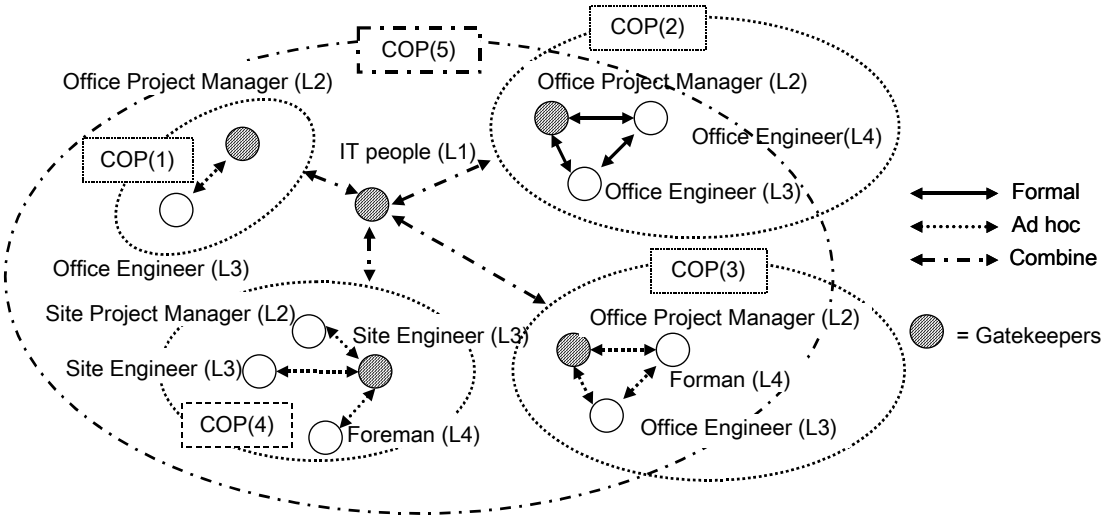

Figure 1: Case study A's communities of practice

used by CSA consisted of main processes such as tendering, project communication, and construction database applications. This study focused on project communication.

Figure 1 illustrates five examples of COP that facilitated the ICT diffusion. One of the senior engineers had a role in validating the ICT initiative and informally created the development of COP(1) with staff from the firm's IT department. When he experienced problems with using ICT applications from a practical and/or technical perspective, he would resolve them with the IT people.

One office project manager helped establish COP(2) by providing time in the morning to talk and exchange ICT knowledge with his colleagues. He spent his morning time providing specific training and discussion about ICT problems with his subordinates and encouraged their feedback and participation. COP(2) assisted the diffusion of ICT through this team because it shared problems and new ideas on how to apply ICT to assist traditional work processes. In addition, COP(2) facilitated additional feedback to be channelled between users and ICT tool developers. COP(3) is a different group of individuals that often communally solved *ad hoc* problems through the gatekeeper, usually by phone, and if they could not through IT people. COP(4) also solved *ad hoc* problems, but on a one-to-one basis through the gatekeeper linked to IT people.

COP (5) used an email discussion group to facilitate ICT use, to communicate with each other to get help. COP (5) helped users who had problems with relation to the ICT use. Members post their questions and the IT staff for other COPs to respond to. Users shared their experiences and problems and also suggested solutions. This reduced repeated questions on the use of ICT and reduces IT staff workload in repeatedly responding to the same problems.

Case Study B (CSB)

CSB is one of the largest construction companies in Australian. The company consisted of many core business units including design, construction and project management. In 1997, the managers from construction e-business unit set up the IT strategy on the benefits of using ICT. To gain a competitive advantage from using Internet technology, the company evaluated the ICT application that might be used in CSB. However, there was no suitable ICT application available at that time for the company's needs. Therefore, CSB decided to design and develop its own ICT tool.

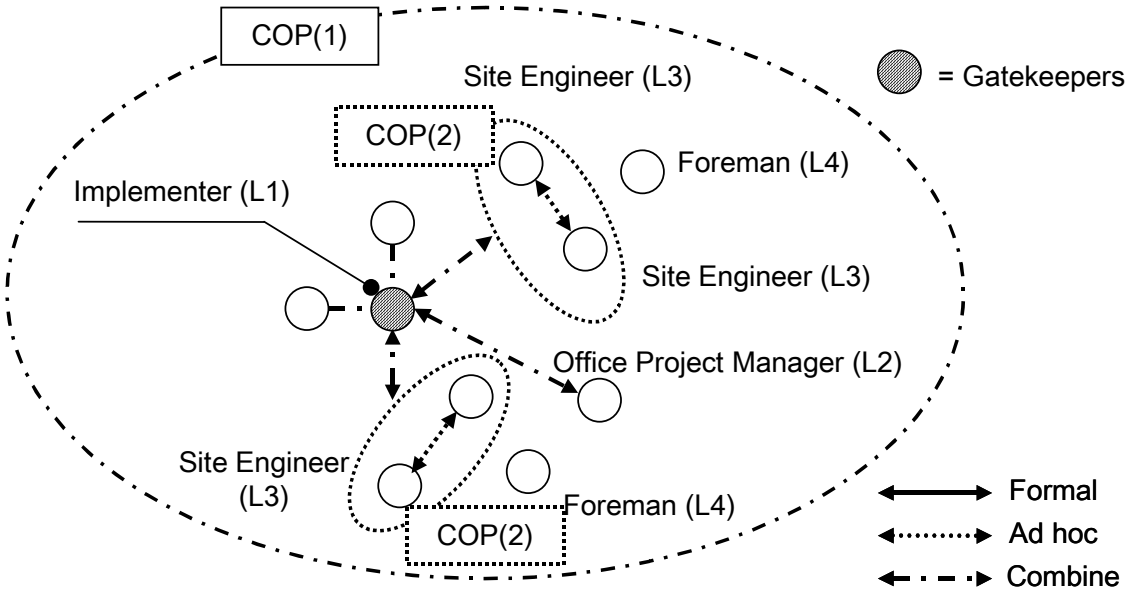

Figure 2: Case study B's communities of practice

The development of ICT was initiated by a CSB group that consisted of experts from many construction fields such as architecture and design, project management, and construction. These experts worked together with developers from an IT consultant company that has the key responsibility in programming the ICT, whereas experts provided the knowledge of technical aspects of construction processes. Additionally, the group was strongly supported by an ICT project-initiating sponsor.

Although the objective of the ICT application was to improve communicate and coordinate of construction project information, participants provided mixed opinions about ICT usefulness. The reason for this is that the ICT was designed to facilitate managing construction projects. Therefore, it may not be perceived as useful for design managers who were not involved with construction activities. In addition it was rarely used by all project parties thus inevitable duplication of both electronic and manual document transfer effort occurred.

Figure 2 illustrates two examples of COP that facilitated the ICT diffusion. At the organizational level, ICT use depended upon the implementer who had most technical knowledge. The implementer was at the centre of and developed COP (1) associated with use of the all-embracing ICT web application. He transferred his knowledge to users and also received feedback from COP (1) and used email and phones extensively to communicate and help solve problems of ICT users. Thus, a virtual COP to improve effective ICT use was created. In general, CSB presented a strong culture of helping each other (not limited to IT issues but also people can ask the help from many expertises in CSB). At the project level, use of ICT discussion and help by COP (2) started with colleagues who worked on the same construction project. Most participants confirmed that they sometimes share and exchange ICT use knowledge. However, they had time and knowledge ICT limitations. Technical ICT assistance was mainly received from implementers. In addition, construction foremen have more responsibility for construction technique aspects, while site engineers, project administrators, and project managers handled most administrative tasks. COP (2) indicates the frequent situation where very small groups that helped each other formed and disbanded mainly for ICT issues to be solved at a low functionality level, because

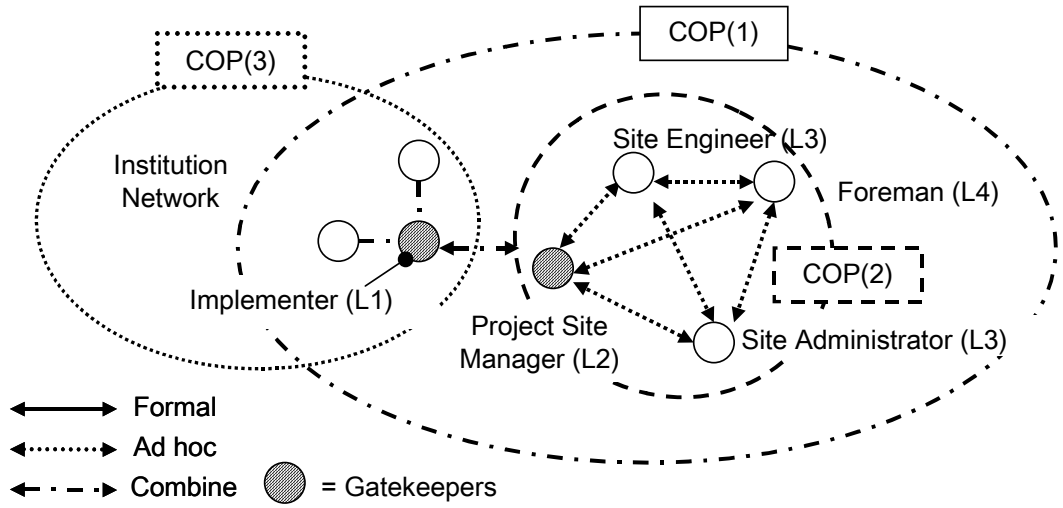

Figure 3: Case study C's community of practice

they tended to get help from the ICT implementer when trying to use the ICT application at higher functionality levels.

Case Study C (CSC)

CSC is a highly innovative Australian construction contractor. The company has an annual global workload of over 1 billion AUS$. Their projects include building and civil engineering infrastructure. This company received several awards relating to construction innovation and have a sound absorptive capacity. The company has strong policy support for improvement of construction productivity and safety. At the time of this study, their commitment to using ICT was project-by-project based. They briefed project participants to provide them with an understanding of benefits of using ICT. After obtaining commitment for ICT use from CSC project managers and other main project participants (such as client, design consultants), the implementer would provide training for project participants and expected CSC users.

An external project web service developed the ICT application. The implementer also had a role in facilitated customization of the ICT application to suit the company's work processes and provided strong support for diffusion of ICT within CSC and other project participants. The strength of COP (1) in Figure 3 is mainly dependent upon the implementer who had the knowledge and background of both the construction and computer context. He started his own communities by providing training on how to use the application for his teams and main project participants.

In addition to COP (1), the implementer, interacts in COP (2) a COP of colleagues. Several COP (2) existed for collegial help and they have a positive influence on novice engineers who did not receive any training sessions to develop skills and be able to use the ICT application. A COP (2) member mentioned that his senior engineer helped him use the ICT application. The project manager also encouraged and helped his sub-ordinates by providing advice on ICT use. Although he has limited knowledge, he tried to resolve problems regarding to its use through the implementer.

COP (3) is the organization-wide network for each business group. CSC started the technology centre with its key functions being to promote and expand a range of ICT technological innovations into business units (BUs). The centre aimed to improve work performance, safety, and quality in construction work processes. It consisted of people who were 'the experts' from different BUs across the organization. They

dedicated time to meet every 3-4 months. The technology centre provided support and advice to BUs on adopting ICT innovation initiated and supported by all BUs.

DISCUSSIONS

In all three cases it was clear that the IT groups held a significant and pivotal position in ICT diffusion through a combination of help-desk one-to-one and one-to-many communication channels. The use of groupware for email and Intranet access for resolving diffusion issues was also substantial in all three cases. Rich communication channels were also used—the COP provided reflection and feedback, facilitating interrogation and ideas clarification/testing. From the three cases, several types of COP networks emerge: institutional, implementer or technical support; project manager/engineer focussed; and collegial support. Each has its individual focus, resources and behaviour/attitude implications.

Institutional Network

An institutional network is defined as a strategic group, interested in development of technology innovation within an organization. Development of ICT required staff that had construction processes experience in all three cases—the aim is for business process needs to drive ICT development so customization, testing and piloting, feedback and fine-tuning is required to be delivered by construction management experts and ICT experts. This COP principally links business process domain experts with an ICT strategist. Resources required include high-level domain expert input and substantial face-to-face time with reflective management behaviour.

The introduction of ICT in CSA was developed from a meeting of regional managers on quality and safety environment, quality assurance manager, and IT experts. This group also dedicated time for testing ICT and designing simple user-interfaces. This type of COP was a temporary one, formed until the objectives of ICT development had been defined and rolled-out. After the development of the ICT initiative, the IT department took over implementation responsibility. Similar to CSA, ICT in CSB was developed by senior mangers with expertise in construction from the e-business group and IT consultants who identified relevant ICT opportunities. This group has been formed to design and develop the ICT tool for developing and managing construction projects. Therefore, the initiative group of CSA and CSB may be classified as *a task-oriented team* (Storck and Hill 2000).

CSC initiated a technology centre to promote and explore technological innovation relevant to its BUs. Groups of people with backgrounds from various BUs across the organization dedicated time to formally explore and discuss the opportunities of using the technological innovation in construction processes. Thus the initiative group of CSC may be classified as *a strategic community alliance* (Storck and Hill 2000).

Implementer or Technical Support Network

CSB and CSC had a key champion with sufficient drive and enthusiasm to be the ICT initiative implementer who envisioned the ICT strategy. A COP would then be built or emerge, nurturing the ICT implementer whose role is to transfer ICT knowledge within project teams to expected users. The implementer plays a significant role in training and being a mentor to users who have a background of construction processes sufficient to understand any potential problems and/or implications of using ICT in construction processes. This person would also be involved with the software company who provided the ICT service and would participate in the development of

the ICT initiative. CSA was dependent on the ICT team for training and development. Typically implementers reside at the hub of the COP; they are the organization's experts and main resource in making sense of the ICT and its development. They require resources to sustain the COP that links and permits ICT initiative knowledge to be cross-levelled and diffused widely across the organization, as suggested by (Nonaka and Takeuchi 1995). Their behaviour is supportive, inclusive and that of an enthusiastic knowledge activist (Von Krough, Ichijo and Takeuchi 2000).

Project Manager/Engineer and Collegial Support Network

From the interviews, project managers play the significant role in ICT diffusion by developing their own community of practice. One of the office managers in CSA mentioned that his team use part of the morning time to discuss how to best use ICT. He found it very helpful for new engineers who received ICT training but may take time to understand how to apply it in their work. He also attempted to support resources for delivery and feedback from end-users to IT staff to improve the application to meet end-user needs.

Furthermore collegial network being considered as the first source of help to users (who have limited ICT knowledge) is consistent with a study of 2000 aerospace engineers who found that well-informed technological gatekeepers with an intimate knowledge of the technical tasks being undertaken were the preferred first choice for finding salient information or knowledge (Anderson *et al.* 2001:151). Personal communication with a peer who knows the context of the problem provides a rich and clearer communication channel for assistance. It often allows users to observe and learn from real examples by real or virtual demonstration (Anderson *et al.* 2001:151). It is easier and quicker to get help from colleagues relating to ICT use.

The existence of the within workgroup COP such as CSA COP(2, 3, 4) and CSC COP (2) link colleagues together as well as providing gatekeepers to the ICT support COP members. In CSA COP (4) the pattern was individuals interacting on a one-to-one basis with the gatekeeper through to the ICT support group. In this kind of COP from a collegial perspective there is a dyad relationship in which the gatekeeper supports the user and learns, filters and consolidates typical difficulties colleagues experience with ICT application. This is then fed back to the ICT developers and the gatekeeper becomes a valuable focal point in that COP. However, the value of colleague interaction is minimized, compared to the more connected CSA COP (2 or 3) in which there is more cross group interaction. A more isolating COP model is evident in CSB COP (1) where most of the help is gained from a dyad relationship between the ICT implementer and people in that COP. In this example it is necessary for temporary or small scale COP to emerge as illustrated in COP (2) but often their skill level for answering urgent questions is limited.

The resource implications for collegial support can be summarized as committed gatekeepers who are provided with the means and their motivation is maintained to support the COP. Additionally, any COP that is linked via groupware needs that ICT application to be effectively diffused for it to be of use. There needs to be an attitude and behaviour consistent with openness, knowledge-sharing and also motivation and rewards for participation, even if rewards are intrinsic (Nahapiet and Ghoshal 1998).

CONCLUSIONS

This paper presented the results of the empirical research on the diffusion of ICT within three large Australian global construction organizations with particular

reference to the way in which COP plays an important role in ICT diffusion. The findings presented here support findings from the broader 3-year study into ICT diffusion study relating to the importance of training and support of ICT diffusion. In addition, the paper presents three types of COP that may represent sound business practice in ICT diffusion: institutional COP that help set the strategic direction for ICT development and validating; implementer or technical support COP that link users with ICT support staff through gatekeepers that can help with the process of interpretation and re-framing problems and difficulties, supporting work group COP that provide the gatekeepers referred in the technical support COP; project manager/engineer network and collegial support COP that provides much of the necessary one-to-one or small group support.

This paper is limited by its scope and a number of interesting questions, such as the degree of ease or difficulty with which these COP are developed; the nature and degree of COP connectivity, access to knowledge and recruiting the right people with required knowledge and the learning culture environment. However, the paper's relevance and contribution lies with its connection to the concepts of a COP and the exploration of the nature of the social networks that it generates, as well as its relevance to the domain of ICT diffusion.

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