CRC Construction Innovation

BUILDING OUR FUTURE

Generic Skills in Design Teams: Literature Review

Research Project No: 2002-024-B-03

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Research Program: B
Sustainable Built Assets

Project: 2002-024-B
Supply Chain Sustainability

Date: 2 July 2004

Leaders in Construction and Property Research

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1. PREFACE

The Cooperative Research Centre for Construction Innovation (CRC-CI) research project 2002-024-B: ‘Team Collaboration in High Bandwidth Environments’, is supported by a number of Australian Industry, government and university based project partners: University of Sydney; University of Newcastle; CSIRO; Woods Bagot Pty and Ove Arup Pty Ltd.

This report has been produced by the University of Newcastle in collaboration with all of the other project partners.

2. EXECUTIVE SUMMARY

Recent developments in networked three dimensional (3D) virtual worlds, and the proliferation of high bandwidth communications technology, have the potential to dramatically improve collaboration in the construction industry.

This research project focuses on the early stages of a construction project in which the models for the project are developed and revised. The project investigates three aspects of collaboration in virtual environments:

1. The **processes** that enable effective collaboration using high bandwidth information communication technology (ICT);
2. The **models** that allow for multiple disciplines to share their views in a synchronous virtual environment;
3. The **generic skills** used by individuals and teams when engaging with high bandwidth information communication technology.

The third aspect of the project, listed above, led by the University of Newcastle, explores the domain of **People** and the extent to which they contribute to the effectiveness of virtual teams. This report relates, primarily, to this aspect.

It reviews and presents literature on the issues of teamwork, virtual teaming, generic skills involved with teamwork, and virtual teams. These themes are examined in the environment of early design from the perspective of a broad range of industries. The literature is then evaluated in relation to the overall research project's aims and objectives, concentrating on the areas of: teamwork, virtual teams, generic skills and early design.

The objective of this report is therefore to:

- Analyse literature within the domain of design, supported by literature drawn from the broader domain of remote collaboration to identify factors of virtual teaming which may affect team member skills.

Environmental and technological changes have impacted on the way in which construction teams function. A major driver of environmental change has been a move towards more collaborative contractual arrangements, such as alliancing and partnering, which, in turn, promotes technological change. Longer term relationships between project team participants act as drivers for the uptake of new technologies. Investing time and money in new computer hardware and software is more attractive if such technologies can be used on many projects, with the same people.

With regard to the nature of teams, technology (i.e. cost of technology, speed of information transfer and the associated costs) promotes moves from co-located to more virtual team activities. However, the challenge of such a move is to incorporate aspects of co-location, for example, seeing people whilst interacting with them, and the ability to collaborate on issues such as developing an aspect of a design, within a virtual environment.

The report concludes that in order to function efficiently and effectively in a team environment, irrespective of whether it is a traditional or virtual team, team participants require '*appropriate skills*' (i.e. awareness, understanding, and abilities to apply). One cannot '*assume*' that all team members automatically possess all of the necessary skills for virtual teaming. Previous research has identified that the introduction of new technologies can impact, both positively and negatively, upon the performance of teams. Therefore the ability to map and measure the skills of individuals and teams is seen as critical. Mapping and measuring these skills will lead to training in any deficient areas identified. The development of skills mapping and measurement tools will be the major outcome of this aspect of the

research project. The next phase will take the first of a series of steps by developing a framework for the analysis of design team activity categorising activities and skills.

3. BACKGROUND

Recent developments in networked 3D virtual worlds and the proliferation of high bandwidth communications technology have the potential to dramatically improve collaboration in the construction industry. There have been numerous studies of collaboration in Europe and the USA that have resulted in system architectures to support data transfer and information sharing. This project focuses on how these systems and the associated commercial tools can be used in a high bandwidth environment. It focuses on the early stages of a construction project in which the models for the project are being developed and revised. The project looks at three aspects of collaboration in virtual environments:

1. The **processes** that enable effective collaboration using high bandwidth information communication technology.
2. The **models** that allow for multiple disciplines to share their views in a synchronous virtual environment.
3. The **generic skills** used by individuals and teams when engaging with high bandwidth information and communication technology (ICT).

The third aspect of the project, led by the University of Newcastle, explores the **People** domain, and the extent to which they contribute to the effectiveness of virtual teams within the industry. This will be accomplished within the context of tools developed by the other two aspects (1 & 2) defined above. Relevant literature has been reviewed, and this is followed by the collection and analysis of data, mapping the factors which influence effectiveness across the domains identified above. Then conclusions are drawn which facilitate the development of skill profiles for virtual team participants. It is envisaged that the development of skills profiles, both at the individual and team levels, will provide the basis for work based training, feeding into educational and continuing professional development (CPD) programs. The scope of the *generic skills* aspect of this project is limited to the early design phase experiments developed and implemented by the University of Sydney.

The genesis of research into virtual teams and skills came from a previous CRC-CI research project (Project Team Integration: Communication, Coordination and Decision Support [2001-008-C-04] conducted at the University of Newcastle (Kajewski, 2003). One component of this scoping study investigated issues relevant to project teams working in virtual environments. A case study was conducted where project team supply chain participants (from client representative to subcontractors), in a recently completed construction project, were interviewed. The project used a web portal for communication between team members. Although there was consensus that the case study project team possessed the skills required to execute their responsibilities, most interviewees acknowledged that they had learnt and / or developed skills on the project, but found it difficult to identify the particular aspects / areas that had been learned / developed. With respect to the impact of Information and Communication Technologies (ICT) and construction professionals engaging electronically in teams, the identification of the mix of skills required to operate in such environments will facilitate targeted (rather than ad-hoc) skills development programs. Goulding and Alshawi (2002; p501) noted that managers are, *"….continually striving to match market opportunities with core competence, and increased importance is being placed on understanding how skills (and competence) contribute to organizational performance*." An audit of the skills of participants in the construction supply chain will provide this strategic advantage as well as a focus for the identification of appropriate skills development opportunities.

A recommendation from this research, based upon its key findings, for further research was to identify and audit construction project virtual teams. Therefore this research seeks to investigate further, and specifically, project team skills, focusing, in particular, on design professionals.

This literature review begins by presenting a series of areas of relevance to teams working in virtual environments:

- Teamwork
- Composition and nature of teams
- Generic Skills, and
- Design team activities.

Then key issues relating to the above areas are then discussed. Conclusions are drawn and actions for the next phase of the research outlined.

4. AIMS AND OBJECTIVES FOR THE PROJECT AND THE LITERATURE REVIEW

Technology is continually changing throughout the entire construction industry; and particularly in the design process. One of the principal manifestations of this is a move away from team working in a shared work space to team working in a virtual space, using increasingly sophisticated electronic media. Due to the significant operating differences when working in shared and virtual spaces (discussed later) adjustments to generic skills utilised by members is a necessity when moving between the two conditions. This aspect, led by the University of Newcastle, is based on research of **generic skills** used by individuals and teams when engaging with high bandwidth information and communication technologies (ICT). It aligns with the other two aspects of collaboration in virtual environments, **processes** and **models**, which is being led by the University of Sydney. The entire project focuses on the early stages of a project (i.e. design) in which models for the project are being developed and revised.

4.1 Research Aims

The aims of this aspect of the research project, as stated in the CRC-CI contract are to:

1. Map and develop personal and team-working generic skills of virtual team members working in the design stage of construction projects, and,
2. Specify requirements to enable Construction Industry individuals and teams to operate effectively in CRC-CI ICT assisted environments during the design stage of construction projects.

4.2 Research Objectives

The objectives of this aspect of the research project are to:

a) Develop guidelines for the analysis of design teams and their participants whilst designing in virtual environments;
b) Develop terms of reference for the conduct of interviews and/or focus groups with design teams and their participants;
c) Analyse and document experience of collaboration amongst design teams and their members whilst working in virtual environments;
d) Analyse and document skills profiles required for different forms of collaboration in virtual environments, and
e) Report on the knowledge, skills, and attitudes required to effectively participate in design teams in virtual environments.

4.3 Literature Review: Research Context

This review aims to present literature on the issues of teamwork, virtual teaming, generic skills involved with teamwork and virtual teams. These themes are examined in the environment of early design from a broad range of industries. The literature is then evaluated in relation to the stated research aims and objectives, concentrating on the areas of teamwork, virtual teams, generic skills and early design. Therefore the objective of this report is to analyse literature within the domain of design, supported by literature drawn from the broader domain of remote collaboration. The outcomes of this review will inform the next phase of the research: the development of a framework for the analysis of design team activity.

5. TEAMWORK

As time and technology move forward, and design projects become more complex, relationships, roles, and responsibilities have become more varied. It is through the sharing of ideas that superior products are created and delays and miscommunication are avoided (Maher et al., 2000a). Teams are a cluster of two or more people usually of differing roles and skill levels who interact '*…adaptively, interdependently, and dynamically towards a common and valued goal.*' (Salas et al., 2000). They are the vehicle for the process of collaboration (Beyerlein et al., 2003). In a majority of organisations there exists a wide variety of challenges and issues. The key issues and challenges are discussed below. The following sections investigate, by definition and discussion, project teams and their life-cycles and processes.

5.1 Definitions of Operational and Project Teams

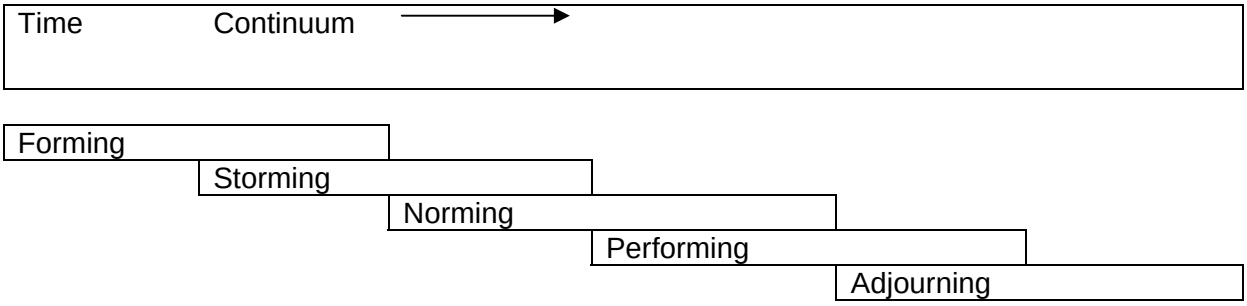
Literature tends to classify teams into two facets: 'operational' and 'project'. Operational teams are stable teams existing in the same business environment (Jaafari and Tooher, 2002). Stable refers to the fact that those members are fixed and the team operates for an extended period of time over many projects. Teams which form for a specific project are defined as project teams (Jaafari and Tooher, 2002)**.** These teams are primarily formed quickly and disbanded in the same manner. They are often comprised of members from different backgrounds (i.e. professions) who bring specialised skills to a project. Project teams often have multiple points of authority between the team members, and share '*…decisions, results, and rewards…'* (Cleland and Ireland, 2002). Project teams form the basis of the review of virtual team literature as this research encompasses the early design process, which in the majority of cases, draws designers together for a specific project.

An historical trend in the construction industry has been that each time a project team is formed the make up of it's members (both at an individual and organisational level) changes, resulting in little or no consistency of membership (Emmitt and Gorse, 2003). However, more recent trends, promoted in particular by large private and, more recently, public sector clients has led to the use of more 'collaborative' procurement systems such as 'strategic alliancing' and 'partnering' (Love et al., 2002). Such alliances have, to some extent, encouraged and promoted the developments and utilisation of newer technologies given that they promote longer term relationships between participants and thus encourage investment and utilisation of such technologies. For example, strategic partnering is used by companies to obtain advantages from long term cooperative work on more than one particular project (Love et al., 2002). Therefore changes to the structure of the construction industry, in particular longer term 'alliances', to work together on multiple projects, between different organisations, are seen as a driver of technological change and uptake.

5.2 Project team lifecycle and processes

There is a significant degree of consensus between authors on the life cycle of a project team based upon Tuckman's (1965) model (Lipnack and Stamps, 2000, Blair, 1991, Jaafari and Tooher, 2002). Figure 5.2.1, developed from Lipnack and Stamp's (2000) work, illustrates stages in the project team lifecycle.

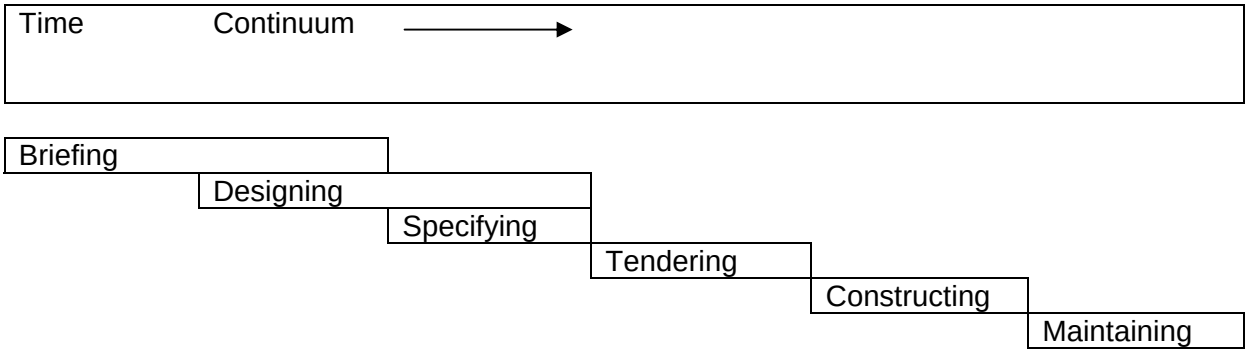
Figure 5.2.1 Model of stages in the project team lifecycle (based on Lipnack and Stamps, 2000).



'Forming' refers to the early development stage where all communication is directed by emergent leaders (Lipnack and Stamps, 2000, Tuckman, 1965, Blair, 1991). 'Storming' is the next stage which is associated with little communication and an increase in conflict between team members. The 'Norming' stage involves an opening of communication channels and a free flow of information with all members expressing their individual ideas. In 'Performing' a team system is established and project results are revealed (Lipnack and Stamps, 2000, Tuckman, 1965, Blair, 1991). According to Jafaari (2002) and Lipnack and Stamps (2000) there is one final stage, 'Adjourning', which encompasses the annulment of a team. This stage involves the slowing of work processes as the final product is delivered and feedback is sought. Feedback at this stage could result in a team ending interaction or moving to a new stage. However, this is dependent upon the particular design task (Lipnack and Stamps, 2000).

It is interesting and relevant to juxtapose the project team lifecycle shown in Figure 5.2.1 with Cornick and Mather's (1999) model describing a generic model of the stages in a construction project team lifecycle, Figure 5.2.2.

Figure 5.2.2 Generic construction model of the stages of a project team lifecycle (based on Cornick and Mather, 1999).



'Briefing' refers to the phase of construction where the requirements of a project are identified (Cornick and Mather, 1999). 'Designing' encompasses the proposal and agreement stages of the design solutions. 'Specifying' is the defining of those production necessities for the construction process. 'Tendering' is the process through which prices are determined for the production necessities. 'Construction' and 'Maintaining' are respectively the physical production of the project and the post construction care and management of the project (Cornick and Mather, 1999).

This model demonstrates an alignment, in terms of the time continuum, with the 'Generic construction model of the project team lifecycle' in Figure 5.2.2 as illustrated by Cornick and Mather (1999), except that it refers to the actual conceptual processes, creation and refining

of a design rather than the phases of social interaction. Each of the construction stages, as defined by(Cornick and Mather, 1999) can be compared with Lipnack and Stamps's (2000) stages of the project lifecycle, as shown in Table 5.2.1.

Table 5.2.1 Comparison of Lipnack and Stamp (2000), and Cornick and Mather (1999) models.

Lipnack and Stamp Stage	Cornick and Mather Stage	Comparison
Forming	Briefing	Project team comes together to identify and define project requirements
Storming	Designing	Presentation of solutions to design problems with potential for conflict as designs presented
Norming	Specifying	Design finalised and translated into information to enable construction / building services to be procured
	Tendering	No equivalent stage in the Lipnack and Stamps model, due to construction domain process specificity
Performing	Constructing	Translation of a design into a physical artifact
Adjourning	Maintaining	Construction of facility completed and team generally disbanded (unless some form of BOOT project). Feedback on project and team performance i.e. debriefing)

Collaborative teamwork in a construction context historically refers to a short term alliance (i.e. for a single project) between parties or companies. Cooperation is the term used to describe the relationship between companies that would exist for more than one project (Love et al., 2002). Maher et. al. (2000a) report three different styles of design collaboration, within a collaborative design experiment, as shown in Table 5.2.2.

Table 5.2.2 Differing collaboration styles (as indicated by Maher et al. 2000a)

Collaboration Style	Description
Constant collaboration	Designers work on the entire design entity while consulting with each other.
Intermittent collaboration	Designers work on different sections of the design, and check with each other intermittently.
Leader controlled collaboration	There is an establishment of a leader who directs the members to specific design tasks.

These types of collaboration all need to be supported in any mode of team, whether co-located, virtual or global virtual.

6. COMPOSITION AND NATURE OF TEAMS

Before examining the skills involved with teamwork and how they may be affected by virtual technologies, the composition and nature of teams requires definition. A succinct summary is provided by McDonough et al (2001; p 111) who categorises various types of teams, as follows:

- **Co-located teams** are comprised of individuals who work together in the same physical location and are culturally similar.
- **Virtual teams** are comprised of individuals who have a moderate level of physical proximity and are culturally similar. One example of virtual team is where team members are in the same building but on different floors.
- **Global teams** are comprised of individuals who work and live in different countries and are culturally diverse.

Each of the above categories is discussed below, before comparisons and challenges are discussed.

6.1 Definition of Co-located Teams

Historically co-location was the principal way that teams operated before technology provided the ability to communicate with others in different physical locations. Co-located teams are those whose members operate in the same physical and cultural space (McDonough III et al., 2001). Co-located teams' interactions are synchronous, occur in a similar place, and their members may be culturally different in terms of different organisations. It is thought that team strength is a result of this social face-to-face (co-located) interaction with team members at work and outside of work (Lurey and Raisinghani, 2001). However, with increasing globalisation of projects it is becoming harder to co-locate these national and global team members (McDonough III et al., 2001). Lipnack and Stamps (2000) suggest that in the North American culture, team members need to be physically close to operate effectively, reporting that if members are more than 50 feet apart the number of team interactions begins to drop dramatically.

6.2 Definition of Virtual Teams

Virtual teams exist when those members of a team are culturally similar but operate, for the majority of their existence, in different physical spaces such as different cities within the same country (Lurey and Raisinghani, 2001, McDonough III et al., 2001). Kimble et al (2000) classify virtual teamworking by defining three dimensions, each with two variables, as shown in table 6.2.

Table 6.2 A classification of virtual team working (Kimble et al, 2000)

	Place	
Time	Same	Different
Same	*Co-located*	*Synchronous Virtual*
Different		*Asynchronous Virtual*

As the clients of the construction industry demand more efficient and higher quality services the need to utilise different dimensions and variables on a project increases. Consequently

instead of an architect conceptually designing a structure and then seeking approval from a structural engineer, an engineer may be involved from the beginning of a project to advise on pertinent issues (Kayworth and Leidner, 2000). This need for group interaction has led to an increase in partnering between construction organisations from different disciplines (Love et al., 2002). Therefore, due to the different geographical locations of project team members, more complex and sophisticated electronic media are being used to communicate ideas and designs (Jaafari and Tooher, 2002).

6.3 Definition of Global Teams

A global virtual team exists when team members are also culturally displaced, such as in international collaborative ventures (Kayworth and Leidner, 2000). The majority of definitions of global virtual teams suggest that they are temporary in nature with a lifespan related to a specific project (Jarvenpaa and Liedner, 1998). The most important characteristics of a virtual team are the organisation and planning stages, without which the team will never have a solid foundation from which to run everyday operations (Cantu, 1997). The reasons why planning is so important is primarily concerned with the challenges facing virtual teams, which will be considered further in section 6.6.

6.4 Comparison between Co-located and Virtual Teams

According to Lurey and Raisinghani (2001) there is little difference in the issues that face a co-located team when compared with a virtual team; they are both '*...first and foremost teams.*' (Lurey and Raisinghani, 2001).

Co-located teams are always synchronous, meaning that they meet and exchange information at the same time, while virtual teams can be both synchronous and asynchronous. Where at times they will discuss a project in real time (i.e. via video conferencing and web chat programs) the majority of methods involved email or electronic bulletin boards with a temporal distortion of received material (Maher et al., 2000a). Table 6.4, adapted from Maher et al (2000a), gives a portrayal of each of the most common forms of team interaction. With the co-located category added, it can be seen that not all virtual methods offer the same array of information, or synchronicity. However, due to time zone differences (i.e. in global teams) the concept of synchronicity is sometimes not relevant to global virtual teams (Kayworth and Leidner, 2000).

Table 6.4 Communication options for teams including temporal aspects (adapted from Maher et al 2000a).

Type of communication	**Temporal aspect**	**Media**
Email	Asynchronous	Text, Data files
List serves	Asynchronous	Text, Data files
Bulletin boards	Asynchronous	Text, Data files
Talk, chat	Synchronous	Text
Broadcast	Synchronous	Video, Audio
Video conferencing	Synchronous	Video, Audio, Images, Text
Co-located	*Synchronous*	*All*

6.5 Advantages of Working in a Virtual Team

With the spread of organisations across the globe, and the increase in industrial alliances, virtual teams have become necessary to achieve efficiency, performance, knowledge, stable relationships, and client satisfaction (Gameson and Sher, 2002b). Organisations are able to increase the amount of knowledge and expertise they have on a project without the need for actual face-to-face meetings, lowering travel time and expenditure. Initially advantages may be seen when those members of a virtual team do not have a shared understanding of the project concepts (i.e. a mental model) in question. Without this shared understanding they must form their own understanding of the concepts. This is done through questioning and in most cases this method of establishing a shared mental model will highlight areas of weakness or error (Stempfle and Badke-Schaub, 2002). For this reason teams with different cultures often out perform those with homogeneous cultures (Stempfle and Badke-Schaub, 2002). Virtual teams are also often able to shorten the production life cycle time, because the work can be done in parallel instead of in a stereotypical production line or serial mode (Lipnack and Stamps, 2000).

6.6 Challenges faced by those in Virtual Teams

With fast development of and changes in technology in most fields it is not inconceivable that virtual teams may soon exhibit the same generic attributes as co-located teams, such as body language. When looking at the skills involved with both co-located and virtual teams it is easy to say that 'technology has all of the answers'; that the same skills seen in a co-located team can be utilised using technology in a virtual team. However, there are other issues to consider, such as: whether team members are operating synchronously or asynchronously, time differences, or whether the technology is available to all members of the team (Williams, 2004).

In a face-to-face meeting all contextual cues can be utilised; these include body language, eye contact, and changes in speech. These give information about the person speaking, how the message is conveyed, and the success of the communication (Driskell et al., 2003). Virtual teams can therefore lose these verbal and visual cues. Without the use of gestures, body language and voice intonation in mediums such as e-mail, there can be significant misunderstandings due only to contextual constraints, that can lead to inter group conflicts (Riedlinger et al., 2004). Jaafari and Tooher (2002) have outlined a number of constraints of the virtual team including:

- The lack of personal contact minimising the ability to use social cues and body language
- A lack of leadership hierarchy within the remote groups
- The members are at the mercy of technology, the communication channels could be severed by a fault in the system.

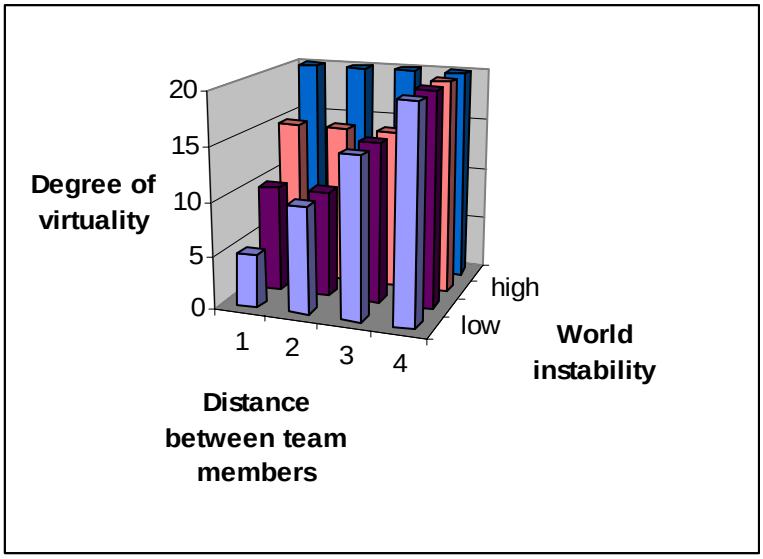
Ensuring that all members of a team have an appropriate level of technical expertise in terms of using communication media is also a challenge that comes with using complex technology (Lahti et al., 2004).

Organisations cannot use the same management strategies in virtual teams that are already in place for operational teams. Members will be unable to complete their tasks when placed in a situation with those from other environments all under different managerial styles (Gameson and Sher, 2002b). A clear definition of roles, responsibilities and objectives is needed to allow for a more structured work environment. The virtual environment is not one that allows open discussion to resolve issues of procedure, and for these reasons clear boundaries and procedures must be created for all levels of membership.

The move towards a virtual world is becoming ever more relevant in today's unstable world environment. The extent to which a team becomes virtual can be affected by a number of

variables including the extent of the distance between members, the number of organisations the members represent, the length of time the team has functioned together (Ratcheva and Vyakaram, 2001), and the experience (i.e. technical skills) of the members (McMahan, 1998). As can be seen in Figure 6.6 The extent of a team's virtuality can also be affected by world instability, such as the events of September 11, so that as distance increases, and people are reluctant to leave home due to international issues, the degree of a team's virtuality increases (Kirkman et al., 2002).

Figure 6.6 Diagram illustrating the variables that can impact on a team's ability or willingness to become virtual (virtuality).



Design professionals, in different design domains (for example manufacturing and construction), have always collaborated. However, as the communicating world becomes smaller, somewhat paradoxically, communication difficulties between team members can increase. While new technologies and prices are making national and international travel easier for team members, cost cutting and economic downturn have seen an increase in the number of virtual teams operating between and within organisations. Whilst there are some challenges faced by those working in virtual teams, the benefits seem to be a selling point. In the long run virtual teams are less expensive and more time efficient, as well as increasing the amount of knowledge and skills within these teams.

7. ISSUES OF GENERIC SKILLS ARISING FROM A VIRTUAL CONTEXT

For the purposes of this literature review, generic skills are defined as the knowledge, skills and attitudes that a team member possesses when completing a task or communicating with fellow members (Salas et al., 2000), whether in a co-located or virtual environment. Skills development and training should be viewed by management as an investment in creating more valuable and skilled employees. Providing team members with the skills needed to communicate in a virtual environment is a long but necessary process (Goulding and Alshawi, 2002), if errors associated with miscommunication are to be avoided.

This section of the literature review gathers information on teamwork dynamics in a broad sense, and analyses its relevance to organisations and industries. In Salas's research involving teams, generic skills have been defined as those that influence both individuals and teams (Salas et al., 2000). They are skills which are *'…transportable and applicable across teams'* (Salas et al., 2000). Table 7 illustrates these skills which form the basis of an effective team (Salas et al., 2000).

Table 7. Integrated teamwork skills as adapted from Cannon-Bowers et al 1995 (Salas et al., 2000).

Core Generic Skills	**Definition**	**Sub skills**
Adaptability	The use of compensatory behaviour and reallocation of resources to adjust strategies based on feedback	• Flexibility • Compensatory behaviour • Dynamic reallocation of functions
Shared situational awareness	When team members have compatible mental models of the environment within and outside of the team.	• Orientation • Team awareness • System awareness • Identity
Performance monitoring and feedback	Ability of team members to give, seek, and receive task clarifying feedback.	• Performance feedback • Acceptance • Mutual performance monitoring • Procedure maintenance
Leadership/team management	Ability to direct and co-ordinate the activities of other team members particularly pertaining to performance, tasks, motivation, and creation of a positive environment.	• Task structuring • Motivation of others • Goal setting • Goal orientation
Interpersonal relations	Ability to optimise the quality of team members' interactions.	• Conflict resolution • Assertiveness • Moral building
Co-ordination	Process, by which team resources, activities	• Task

	and responses are organized to ensure that tasks are integrated, synchronised and completed within established temporal constraints.	organisation • Task interaction • Timing
Communication	Information exchange between members using the prescribed manner and terminology.	• Information exchange • Consulting with others
Decision making	Ability to gather and integrate information, use sound judgment, identify alternatives, select the best solution, and evaluate the consequences.	• Problem assessment • Problem solving • Planning • Implementation

Notwithstanding the numerous skills identified in Table 7, we have elected to focus on those which occur most frequently throughout the literature reviewed. These are now discussed in the following section.

7.1 Core Generic Skills in a Virtual Context

The core generic skills listed in Table 7 are examined here in greater detail, and then analysed as they present in a virtual environment.

7.1.1 Adaptability

The skill of adaptability stems from the need to change in order to be efficient and/or work effectively in the dynamic team situations. For teams moving from co-location to virtual environments, an ability to adapt and change can be a long process riddled with trial and error scenarios. This process is seen as necessary to encourage effective virtual teams (Kirkman et al., 2002).

It may be said that the construction industry is struggling to adapt to newer technologies, changing culture (Baldwin, 2004), and the need for up-skilling in terms of the use of IT in virtual teams. This emphasises the rationale underpinning this project.

7.1.2 Shared situational awareness

Shared situational awareness refers to the skills that allow team members to arrive at a common understanding of a situation and, on the basis of this, to interact and solve problems (Salas et al., 2000). Sonnenwald and Pierce (2000) indicate that it is not only intragroup (within team members) shared situational awareness that teams need to develop skills in, the intergroup (between different teams) shared situational awareness is also important so that team members can be more effective through the goals they are attempting to achieve (Sonnenwald and Pierce, 2000).

7.1.2.1 Identity

When team members speak of a team identity, or an organisation to which they belong, they will often be referring to the information and knowledge a team shares and acts upon. In some cases this sharing of information may take precedence over the need for a shared physical space (Lipnack and Stamps, 2000). With virtual teams, the fact that there is no ‘physically’ shared space is possibly not an identity issue, as there is only a need for ownership of knowledge which can easily be arranged in the virtual world through systems such as shared files. Team members do still need shared areas where the majority of

transactions occur. This is termed a ‘place’, where team members build a sense of community (Lipnack and Stamps, 2000). A virtual system (such as a ‘bulletin board’) for building team identity would need to accommodate two ‘places’: a product place, where an actual project is designed and delivered, and a process place, where running of the teams and organisations occur (Lipnack and Stamps, 2000). This combination would allow team members to operate effectively across physical boundaries (Lipnack and Stamps, 2000).

7.1.3 Performance monitoring and feedback

One the easiest ways to exercise the skill of feedback is to conduct feedback meetings, either at the end of a project or at the end of a phase of a project (Emmitt and Gorse, 2003). The ability to provide feedback is essential if problems in future projects are to be identified (Emmitt and Gorse, 2003).

Kirkman et al’s (2002) case study of Sabre Inc, a travel innovation company, highlighted a number of skills that management recognized as important for a virtual team, and feedback was one of these. In the case of virtual teams, feedback must be a constant process, provided mostly by the team leader (Kayworth and Leidner, 2000) as this person is generally the major coordinator. Within the construction domain feedback can be defined as clarification provided by a messenger to a receiver where an earlier message was not understood. If the communication skills of messengers are not sufficiently developed the use of a multi-channel communication system may be required, such as the combination of telephone, email, and a shared whiteboard (Emmitt and Gorse, 2003).

7.1.4 Team management

7.1.4.1 Project Management

The skills of project management have been recognized as essential as projects become more ‘…global and complex…’ (Vitiello, 2001). Project management uses a set of generic skills to deliver projects within time, scope, and cost, while providing clients with a quality product (Smart, 2004). Vitiello (2001) outlines a list of skills necessary for effective project management (many of which have already been described above):

- Leadership skills
- Communication skills
- Conflict resolution skills
- Negotiation skills
- Listening skills
- Team building skills
- Relationship management skills

Smart (2004) also identifies the following project management skills:

- Planning skills
- Contract management skills
- Problem solving skills

The skills utilised by project managers in co-located teams are quite different to those used in a virtual team (Kayworth and Leidner, 2000). The techniques used to negotiate, resolve conflicts, and communicate change due to the different communication channels in place in these environments i.e. managers would not be able to negotiate one-on-one with a team member, nor would relevant information be close at hand; instead managers would have to exercise more detailed and rich negotiation strategies through an electronic medium (Gameson and Sher, 2002a). Management of a global virtual team would also be difficult because of language and cultural differences This will be especially relevant for management

as it is suggested that managers spend almost 90% of their work time communicating with team members (Cleland and Ireland, 2002).

7.1.4.2 Leadership

While projects are coordinated by project managers, they need skills in leadership, and this is certainly true within the construction industry (Emmitt and Gorse, 2003). Emmitt and Gorse's (2003) experiences show that a project manager who uses an open and inclusive leadership style, and allows a sense of ownership for team members, is more effective than one with an autocratic style. In the context of this research, a sense of ownership refers to the extent to which design professionals discuss problems and have ideas acknowledged by management, whilst maintaining a high level of commitment to their tasks (Emmitt and Gorse, 2003). Whilst some authorities acknowledge that those leadership skills used in a co-located team are similar to those in a virtual team (Dharmawardena, 2003), there are also considerable differences. For a leader to be effective in a virtual world it is necessary to create a more structured and formal environment (Lurey and Raisinghani, 2001, Dharmawardena, 2003). Newer technologies do not necessarily lead to greater team effectiveness; it is the implementation of the human aspects of a team (such as a positive and satisfying work environment) that leaders of virtual teams should seek to facilitate (Lurey and Raisinghani, 2001, Hoyt, 2000).

When leading a virtual team, proactive management skills are essential. Leadership involves taking the time and effort to contact and liaise with team members and to ensure that there are no clashes, be they cultural or personal or otherwise (Cantu, 1997, Kayworth and Leidner, 2000). Lipnack and Stamps (2000) however, suggest that it is the ability of virtual team leaders to influence and guide teams, rather than leading by force that creates an effective virtual environment.

7.1.4.3 Goal setting

An integral part of leadership is the ability to establish goals for the members of a team. Furst et al (1999) explain that goal setting is the ability to '…establish specific, challenging and accepted team goals'. Virtual team leadership is heavily founded on an ability to set clear goals for team members. The ability to deliver timely and appropriate feedback pertaining to these goals then follows (Dharmawardena, 2003).

7.1.5 Interpersonal relations

Interpersonal skills have been cited (Hoyt, 2000) as being of extreme importance to effective teams. They are the skills that allow for the management of conflict and disagreements between members of teams (Stevens and Campion, 1994). When attempting to use interpersonal skills such as peer support in a virtual team setting, the impact of body language may be lost because technologies such as email and telephone conferencing do not communicate them effectively (Hoyt, 2000). Industry case studies, such as that of Sabre Inc mentioned section 7.1.3, indicate that through trial and error, companies have realised the need for a balance between technical skills and interpersonal relations (Kirkman et al., 2002). It would be difficult in situations employing low bandwidth technologies for a team member to provide 'body language' cues to let, for example, a person know that they are being listened to or, for example, to congratulate them in a physical manner [such as a handshake] (Hoyt, 2000).

7.1.5.1 Assertiveness

Assertiveness is the ability to allow others to recognise, by declaring clearly (Blair, 1992), that a team member's…knowledge skills and ideas…' (Smith-Jentsch et al., 1996) are available and important for a team discussion (Smith-Jentsch et al., 1996). Effective assertiveness is about being 'quietly assertive'. Blair (1992) explains that one should acknowledge what other team members have said, clearly state one's point with some supportive evidence, and then attempt to resolve the issue. Assertiveness is about being diplomatic, and allowing all

members to be heard. In a virtual environment assertiveness can be associated with 'flaming' or online conflict (Alonzo and Aiken, 2004). Alonzo and Aiken (2004) define 'flaming' in an online context as '…hostile intentions characterised by words of profanity, obscenity, and insults that inflict harm to a person'. The virtual online world creates an environment where team members may feel inhibited or invincible because they are able to be over-assertive without fear of actual physical harm. Skills in assertiveness involve members being able to state their point without creating unhealthy conflict.

7.1.5.2 Conflict resolution

Conflict within a team is not necessarily a negative element of team processes. Skills in conflict resolution centre around allowing a healthy amount and level of conflict that helps problem solving while discouraging unhealthy levels of conflict (Furst et al., 1999). Functional conflict management techniques (such as exploring differences) may be used in an attempt to solve disputes between team members or teams (Emmitt and Gorse, 2003), while maintaining constructive relationships (Emmitt and Gorse, 2003). Conflict is not necessarily the reason team members get into disputes; it is generally the poor management of conflict by project managers or team leaders (Emmitt and Gorse, 2003) for example '*I'll listen to your unreasonable demands, if you'll consider my unacceptable offer*' (Brilliant, 1970: cited in (Banner and Gagne, 1995). While it may be simple to understand when unhealthy conflict is occurring in a co-located team, with social cues such as menacing stares to full arguments, this diagnosis may be more difficult in virtual environments (Furst et al., 1999). If, when monitoring conflict in a virtual team, a late or rude reply of an email or phone message is discovered it may not be enough to suggest that conflict is becoming unmanageable. The virtual environment creates an atmosphere of 'ambiguous' communication, where it can be difficult to interpret whether a person's communication is promoting unhealthy conflict (Furst et al., 1999).

7.1.6 Co-ordination

Co-ordination of team members is essential for the creation of an efficient and effective working team. It is the ability to synchronise information and the tasks of each team member and thus to control redundant work (Furst et al., 1999). The construction industry is highly fragmented and as a consequence there may be little or no co-ordination between members collaborating on a project (Mohamed, 2003). As a result the construction industry has obtained a reputation for inefficiency (Mohamed, 2003). Co-ordination for the construction industry refers to the ability to deliver 'accurate and timely information' (Emmitt and Gorse, 2003) for decision making and problem solving.

Emmitt and Gorse (2003) have compiled a list of potential sub-skills that contribute to effective co-ordination:

- Ability to convey information with clarity and brevity
- Ability to report accurately
- Ability to be consistent
- Avoidance of redundant and repetitious information
- Checking ability
- Timing of information (Emmitt and Gorse, 2003)

The use of virtual technologies to co-ordinate construction processes should be beneficial to both team members and team management. Effective information co-ordination can reduce conflict significantly (Emmitt and Gorse, 2003) and an ability to record and transmit information will aid in the co-ordination and tracking of decision making (discussed in section 7.2.3).

7.1.7 Communication

Communication according to Chiu (2002) is: *'…the dynamic process in which one person consciously or unconsciously affects the cognition of another through materials or agencies in symbolic ways*'. Artifacts are the most simple of the types of communication, they 'allow the externalization and representation of objects, constraints, form, function, assembly, materials, and so on' (Perry and Sanderson, 1998). They include such things as models or CAD visuals (Perry and Sanderson, 1998). In Perry and Sanderson's (1998) study artifacts such as sketches, large scale printouts, and CAD visuals, were used to communicate ideas between engineers and drafts persons.

When changes in a design are needed these are often presented in the form of a new artifact, so that when a faulty current design is withdrawn a new sketch or CAD visual may be put in its place (Perry and Sanderson, 1998). When these new artifacts are approved it is common practice that the majority of stakeholders initial the work to indicate those who have approved it. This allows a clear communication channel to be established for these stakeholders (Perry and Sanderson, 1998).

Drawing is an important aspect of the communication process within design. Drawings can bridge differences between disciplines and professional jargon (Laseau, 2001). In a virtual environment drawings can be communicated by exchanging electronic files whether by email or in a shared networked space (Maher et al., 2000a).

Three dimensional (3D) virtual worlds have been defined as a '*…single computer-mediated dynamic environment which provides virtual team members with a sense of place'.* (Maher et al., 2000b). They commonly use avatars (3D representations of the team members), which allow the use of body language and emotion to a small degree. Most communication would still be text based, with the communication text appearing along side the relevant avatar (Maher et al., 2000b).

Common practice for virtual teams in their infancy is the creation of shared space in a computer environment for the sharing of files, unfortunately this does not allow for communication (Maher et al., 2000b). Team members need more than just an indication of what other members may be working on, they need a medium through which they may express thoughts and ideas regarding their and others' work.

Communication embodies a large area of research. This review divides communication skills into three areas: verbal communication, non-verbal communication, and receiving communication. These areas may be affected by the virtual world, depending on the technologies and techniques utilised.

7.1.7.1 Verbal Communication

Learning and the majority of team interactions are primarily facilitated by conversation. It is through this skill that one learns the beliefs, and assumptions of team members that form the culture of a team (Gay and Lentini, 1995).

When engaged in conversation in a face-to-face environment, an important aspect is the ability to ask for feedback to ensure that the person one is communicating with is correctly interpreting one's meaning (Blair, 1992). Would this ability be limited in the virtual world? Certainly it would make the process of e-mailing extremely cumbersome with an increase in the number e-mails needed just to confirm interpretation.

In any virtual team the most common solution to conversation barriers is the telephone or, as it is known, tele-presence (Gabriel and Maher, 1999). When teleconferencing is used in place of a co-located meeting, studies have indicated a large fall in time spent socialising, as participants are better able to adhere to the task at hand (Cleland and Ireland, 2002).

However, without members being able to access the same visual information, there may large amounts of miscommunication because of the difficulties of translating a three dimensional object into words (Gabriel and Maher, 1999, Poltrock and Engelbeck, 1999, May and Carter, 2001). Gabriel and Maher's (1999) study indicated there are four types of verbal communication in the design process (Maher et al., 2000b):

1. Communication control (interruptions, floor holding and handovers)
2. Communication technology (discussions of how to use the tools)
3. Social communication (time spent in social conversation, not related to design)
4. Design communication (discussion of design ideas, scope and task)

For the effectiveness of design collaboration settings, a majority of design communication would be advantageous. This majority of design communication interaction occurred in a 3D virtual environment which encompassed an avatar, as opposed to the use of video conferencing (Maher et al., 2000b).

7.1.7.2 Non-verbal communication

Gestures are an important step in the hierarchy of communication (Williams, 2004). Design teams often use gesture to indicate the manipulation of objects in a design (Perry and Sanderson, 1998). In a team situation it is often the non-verbal cues which convey the most meaning; a wink, a raised eye brow, or an ear tug (Hoyt, 2000). These cues, whether created on purpose or accidentally, can give secret or subtle information about project or team dynamics (Cleland and Ireland, 2002).

In experimentation with types of verbal communication for virtual interactions, acknowledged in section 7.1.7.1 above, it has been stated that communication via synchronous typed text rather than conversation (tele-presence) is more advantageous (Gabriel and Maher, 1999, Maher et al., 2000b). Typing conversations allowed more reflection on communication and greater concentration on the design communication. A written record was also generated which could be examined to clarify points of interest (Gabriel and Maher, 1999).

7.1.7.3 Receiving communication

When we think of the skills involved in the communication process, listening (or 'receiving) is not widely mentioned. Listening is the ability to understand communication, to be a receiver. When it is considered that humans can lose up to twenty five percent of the information they listen to (Cleland and Ireland, 2002), perhaps re-evaluation of this aspect is necessary. There is little focus on listening skills in formal education. In addition one's ability to 'receive' can also be effected by emotional aspects relating to the information (Cleland and Ireland, 2002, Emmitt and Gorse, 2003), '*…we only hear what we want to hear'*. The major hurdle with some virtual technologies is ensuring that team members actually receive a communication. Bulletin boards and email do not provide a checking mechanism to indicate that the intended person has actually viewed the communication.

7.1.8 Decision making

When making a decision, the majority of the time there are a limited number of alternatives (Stempfle and Badke-Schaub, 2002). Once an alternative surpasses a predetermined point of satisfaction, a decision is made. Little regard is held for other alternatives (Stempfle and Badke-Schaub, 2002). Decisions in the construction industry are often needed immediately and rarely allow adequate time for all data and perspectives to be considered (Emmitt and Gorse, 2003). As a consequence decision-making by virtual teams is more difficult than when teams are co-located. This is because of the need to clarify positions from a variety of different locations. Interestingly Gorse's (2002) research shows that those groups that are most effective are the ones able to utilise a broader range of communication techniques. This may contribute to a deeper understanding of contributors' opinions and be facilitated by the use of more high bandwidth technology (Emmitt and Gorse, 2003). Most IT technologies

have been created to encourage greater collaboration between members of a construction management team (Emmitt and Gorse, 2003). Industry case studies, such as Sabre Inc, have shown that for decision making in a virtual team, there needs to be on going virtual training (Kirkman et al., 2002). Some studies have suggested that the use of virtual teams can lead to an increase in the time it takes to make decisions and also results in a drop in team cohesion (Driskell et al., 2003).

7.1.8.1 Problem solving

Problem solving is a precursor to decision making and so is appropriate as a sub-skill of decision making (Kirkman et al., 2002). It is the ability to highlight the problems or limitations within a task or team, and then subsequently to put in place appropriate action to remedy it (Furst et al., 1999). With respect to problem solving in the construction industry, it appears that project managers may take different approaches depending upon whom they are consulting (Emmitt and Gorse, 2003). When interacting with those lower in the hierarchy (such as sub-contractors) an informal approach to problem solving is used. However, when solving problems with other professionals, such as engineers or architects, more formal processes are often used. Those involved frequently spend more time evaluating problems before making contact with each other (Emmitt and Gorse, 2003). In the majority of these cases communication between the professions is via virtual methods such as fax or telephone (Emmitt and Gorse, 2003). The use of high bandwidth technologies in problem solving would allow a greater and quicker exchange of relevant information quickly but with increased richness and detail (Gameson and Sher, 2002a).

7.2 Team skills in a virtual context

Team skills are those which are held by team members that affect the performance of a team in which an individual is currently working (Salas et al., 2000). The dominant issues in team skills are presented below.

7.2.1 Trust

Computer mediated communication does not have the infrastructure to support all of the interactions and cues that convey trust between members of a team, such as the ability to convey warmth and compassion (Jarvenpaa and Liedner, 1998, Riedlinger et al., 2004). Because of the highly complex nature of virtual teams and networked organisations trust is a necessity (Lipnack and Stamps, 2000, Mohamed, 2003), and without any face-to-face interaction, members are required to work hard to maintain any level of trust (Lipnack and Stamps, 2000).

Poltrock and Engelbeck (1999) believe that videoconferencing will supply the visual contact thought necessary to facilitate trust. However, trust between team members is affected by a range of factors, not only visual contact. Trust is often simply associated with the amount of effort each of the team members contributes (Lipnack and Stamps, 2000).

Due to the expanse of space between members of a global virtual team, cultures may often clash. Individualism versus collectivism is one variable of culture that can affect the trust level of a team (Jarvenpaa and Liedner, 1998). An individualistic culture is one that promotes the interests of the self before the group, whereas the collectivistic is the opposite. Research has indicated that those from an individualistic perspective are more willing to trust and are better able to enter and leave groups (Jarvenpaa and Liedner, 1998) than those from collectivist cultures.

Trust has been found to be established more quickly if the cultures involved in a team have worked with members of similar cultural backgrounds previously (Jarvenpaa and Liedner, 1998). The collective learning process between virtual team members is an excellent way to begin to build trust as increased communication leads to higher levels of trust, which in turn

creates more communication (Sharp, 1996). Trust is a major component between members of a virtual team, so that even a small level of discontent in the team can be multiplied in virtual environments (McDonough III et al., 2001).

7.2.2 Dealing with cultural issues

Culture may be defined as the values, beliefs and ideals held by a group of individuals. Culture is learned by individuals as they enter groups (Kayworth and Leidner, 2000), and is often a result of religion, nationality, ethnicity or even an individual's organisational affiliation (Kayworth and Leidner, 2000). All tasks completed by team members are affected by their culture. Thus a clash of cultures is a common occurrence in virtual teams. Time management and language are the two major areas of culture clash (Kayworth and Leidner, 2000) perhaps due to the possible different countries and time zone differences these cultures may operate in. Possible solutions to these issues were identified in Kayworth and Leidner's (2000) study which highlighted the following strategies for dealing with cultural issues:

1. Attempt to build skills in cultural awareness in virtual team members
2. Attempt to form virtual teams with members from complementary cultures.

Pena-Mora et al (2000) highlighted the on going work of Krishnamurthy and Fruchter (2000) in illustrating the many issues associated with communication between members of a culturally varied virtual team. These included 'representation', which comprises the issues surrounding the different jargon, labels (Poltrock and Engelbeck, 1999) and terminology utilised by different professionals (Pena-Mora et al., 2000). So when communicating there is a need for increased cultural awareness among virtual team members in a number of areas.

7.2.3 Archiving

Records of construction meetings frequently take the form of minutes. These often result in lost data because of inaccurate recording methods or individual agendas. This can result in a need to go over 'old ground' in the next meeting (Emmitt and Gorse, 2003). Using high bandwidth technology in a virtual team should allow for the direct recording of team minutes into verbal or text streams that can be accessed at any time by team members.

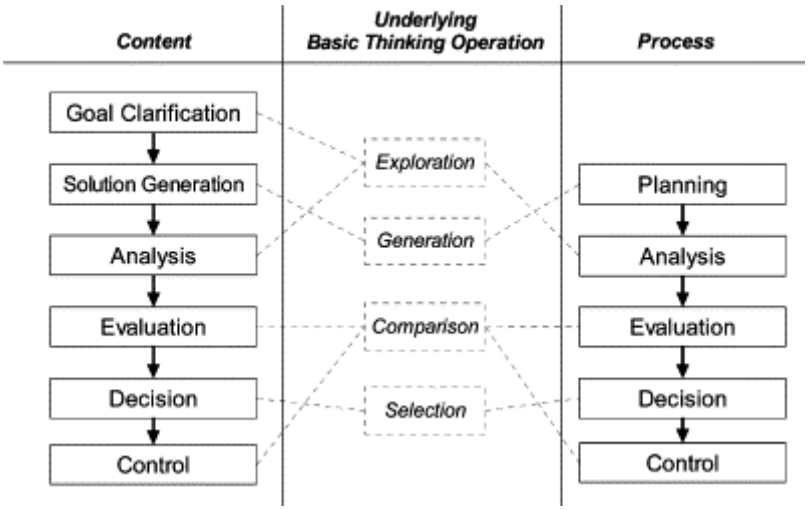
An ability to archive is important for collaboration as it allows members to revisit conversations and decisions made during past team interactions. This is stressed in Pena-Mora et al's (2000) description of CAIRO, an online collaboration agent (a program able to organize and archive the meeting). Within the virtual environment of CAIRO, team meetings are logged under different team agenda headings, allowing members to scroll back and view any discussion on an agenda item of choice (Pena-Mora et al., 2000). A software review by Gallagher and Angus (1998) began by stating that with any teamware application there needs to be the ability to archive decisions (Gallagher and Angus, 1998, Fox et al., 1999) made and rejected so that the information can be sorted and understood in the future (Gallagher and Angus, 1998). The archiving of data for any team will enable an organisation to view successes or problems, and relate these to future team activities (Furst et al., 1999). Archiving in a virtual team would, in some ways, be easier than within co-located environments, providing appropriate software is used; all communications may simply be logged as files and stored on each member's computer (Furst et al., 1999).

8. THE TEAM DESIGN ACTIVITY

Lawson's research (1990) identified collaboration as a large component of designer's working time. Since this acknowledgement of the profile of collaboration there has been a move toward applying research methods to gain a better appreciation of this activity and the skills required to effectively participate in collaborative design processes. In the process of gaining an understanding of design team activities Muir (1995) defined collaboration as the activity of communication between parties involved on a project.

Professionals involved in team-related activities during the process of design undertake a complex multi-faceted process. The collaborative design process is different from traditional design processes undertaken by individual designers. The difference between individual designers and design teams is encapsulated in the collaboration between participants when creating a new artifact. To begin to appreciate the complexity of this collaborative process requires an understanding of the process. Stempfle and Badke-Schaub (2002) developed a model, shown in Figure 8, which conveys the characteristics of both Tuckman's (1965) and Cornick and Mather's (1999) models of project team lifecycle discussed above, in terms of the activities in which designers engage. Like the lifecycle models proposed earlier there appear to be protocol stages, which indicate a consistent process for design teams.

Figure 8 Generic step model of design team activities (Stempfle and Badke-Schaub, 2002).



Stempfle and Badke-Schaub's (2002) model, Figure 8, illustrates the steps which define the processes design teams engage in. The content and process steps of the design team are linked via the cognitive processes underlying the actions of exploration, generation, comparison, and selection.

Similarly Thorpe's (2004) 'Generic Design and Construction Process Protocol' classifies the design collaboration process as a method of project management. Thorpe's project management process is based upon four broad stages:

- Pre-project
- Pre-construction
- Construction
- Post construction

To provide a level of detail of the activities which occur within and across these four stages Thorpe (2004) identified the following phases of the process protocol:

- Demonstrating the need (Phase zero)
- Conception of need (Phase one)
- Outline feasibility (Phase two)
- Substantive feasibility study and outline financial authority (Phase three)
- Outline conceptual design (Phase four)
- Full conceptual design (Phase five)
- Coordinate design, procurement, and full financial authority (Phase six)
- Production information (Phase seven)
- Construction (Phase eight)
- Operation and maintenance (Phase nine)

The similarities between the construction process protocol as described by Thorpe (2004) and stages inherent in the design team lifecycle (Figure 8) illustrate that a process protocol could be established solely for design. These models allow us to understand that design and more importantly collaborative design, is a segmented process, punctuated by 4-5 stages that define design processes. From these similarities it is likely that designs process protocols could be those 'process' steps noted by Stempfle and Badke-Schaub (2002) which consist of the stages proposed by Gay and Lentini (1995). To appreciate the diversity of activity which occurs in the team design process requires an understanding of the range of these activities. Gay and Lentini's (1995) study into deign processes in a collaborative virtual environment defined these activities. Their study identified ten specific activities which occurred in a virtual environment, and these are presented in Table 8:

Table 8. Design activities adapted from Gay and Lentini (1995).

Design Activity	**Definition**
Orientating	Establishing contact, familiarization with task and environment. Period in which members establish themselves and become comfortable in the new environment
Subdividing the problem	Defining tasks, objectives, requirements, and boundaries
Establishing roles	Assigning responsibilities, and leadership issues
Information seeking	Researching skills.
Information sharing	Sharing drawings, communicating pictures, gesturing, reporting on research and progress
Monitoring	Clarification of communication channels
Negotiating/ understanding	Explaining design, commenting and questioning, and justification
Designing	Sketching, visualizing, drawing, and manipulating materials
Building	Not relevant to this review of early design
Evaluating	Scrutinising the project in its duration. (Gay and Lentini, 1995)

The similarities between the 'Generic Design and Construction Process Protocol' (Thorpe, 2004) and ,Stempfle and Badke-Schaub (2002) and Gay and Lentini's (1995), descriptions of design team activity may warrant further investigation to ascertain whether the creation of design team protocol stages is appropriate.

8.1 Issues Impeding Design Team Collaboration

While research has been conducted to define the processes and activities of collaborative design teams, research has also been undertaken to define the processes of implementation and associated issues. In a practical design situation there are a range of difficulties and barriers inhibiting effective practice.

One of the strongest barriers to open and effective collaboration is the professional stereotypes that exist between team members (Muir, 1995, Gil et al., 2001). Muir and Gil cite their experience of observing different professions which related certain perceptions of other professions such as the sports car driving architect, and this can lead to serious divides forming between team members when it comes to effective design collaboration.

Unhealthy conflict (Furst et al., 1999) can be another major barrier often brought about by the above mentioned clash of stereotypes (Emmitt and Gorse, 2003). Distance for the design team is a barrier as the design process is, in the majority of cases (Emmitt and Gorse, 2003), spread across several professions. Team members need only to be on different floors of a building for face-to-face contact to reduce significantly (Lipnack and Stamps, 2000).

Also a consideration in the achievement of effective collaboration is efficient project management. Effective project management involves the "setting and the achieving of mutually agreed goals, and the monitoring of the procedures set up to achieve them" (Muir, 1995). Effective inter-professional collaboration in the design and construction industry requires five objectives, which are:

1. To stop stereotyped attitudes,
2. To improve the flow of information
3. To improve the decision making process, through an understanding of other professionals' values and methods, and through effective channels of communication.
4. Avoiding abortive work through duplication
5. Increasing the cost effectiveness of design procedures (Muir, 1995)

The activity of collaboration within design teams poses a complex set of variables which require management by a design team manager to gain best outcomes.

8.2 The Generic Skills Which Support Design Collaboration

A significant factor in collaborative design team environments is that 'expertise' is paramount in the operation of the team and changes continually. If all 'experts' are narrow specialists they will tend to follow a rational, 'logical' sequential design process from the detail parts to the complex whole (Cowdroy and Williams, 2004). The need is invariably for design to commence based on the identification of a defined outcome (a concept of the completed product as a whole) that is understood and shared by all members of the design team, including those who will be members for only part of the overall design project. To understand and share the concept of the completed product, each member of a team must be able to understand the 'position' of most or all of the other members, and must therefore have some understanding of the design challenges faced by other members. These issues include alternative design possibilities that allow a 'best-fit' among all the design issues of all members.

There is a difference between types of problems in design, well-structured (defined and understood) versus ill-structured (less understood, larger ramifications) (Perry and Sanderson, 1998). This review is restricted to an analysis of ill-structured problems which typically occur in the early stages (design development) of a project. Ill-structured problems require longer periods of communication and the use of a range of artefacts (Perry and Sanderson, 1998). The early design process is an iterative form of problem solving, where as

solutions are formed and constantly revised or redefined to bring to light a satisfactory product (Lahti et al., 2004). Those activities associated with the early design process include: orientating, subdividing the problem, defining roles and planning and analysing problems. The stages of design are not exclusive. Team members move between stages (Lawson, 1997). For example, to complete stage 1 it would be necessary to progress into stage 2; it is difficult to plan a design without analysing the problem. May and Carter's (2001) study into virtual teaming in the European automotive industry found that collaboration in early design phases of a product did not improve the quality of the product. Rather quality was achieved in a shorter time period. The difference was an increase in "first time right decisions" (May and Carter, 2001), which eliminated costly late product construction changes (May and Carter, 2001). Design limitations are discovered through the sharing of information (Lahti et al., 2004) in the early design phase, making it one of the most important phases for collaboration. The next section describes how the early design process may affect some skills when these are exercised in a virtual context.

8.2.1 Leadership

Leadership during early design is important in that it decides the balance of relevant skills and contributions from members to a project (Baird et al., 2000). The leader or leaders need to be able to create teams which identify the important 'social links' between virtual team members (Baird et al., 2000).

When creating a design team, team leaders need to maximize the skill levels of members. This process is constrained in a project with a short timeframe, where it is important for the leader to take advantage of the skills possessed by experienced team members. Advantage is also gained through involving experienced team members in the similar tasks for each new design team (Baird et al., 2000). However, this does slow the training of junior engineers to fulfill these roles. To combat this leaders may choose those with only partial experience in a specific area, but with ability to refer to a senior engineer with expertise and experience for advice (Baird et al., 2000).

In a virtual team the ability of partially trained designers to refer to an experienced source is potentially impaired because of the lack of face-to-face interaction between junior and senior designers. Baird et al (2000) suggests that leaders should allow initial face-to-face contact between these two parties very early in the life cycle as this allows a stronger social link to form and create an environment for effective leadership where training and quality designing can occur.

8.2.2 Co-ordination

To obtain optimal results when designing collaboratively through a virtual medium, co-ordination and structuring skills need to be active in the early design period (Lahti et al., 2004). Lahti et al's study also highlighted the ability of the team members to discuss design in a virtual context. The ability to communicate ideas by making changes to others designs online was not available to their participants; essentially the communication was through a web chat system and email. They felt that not having this virtual aspect somewhat hindered the ability of the design students to communicate ideas.

8.2.3 Feedback

Due to the ill-structured nature of early design processes, an ability to provide feedback is an important skill for team members to possess, particularly vertical communication channels between junior team members and senior decision makers (Baird et al., 2000). An ability to give feedback is crucial at this point because large amounts of information must be validated before progressing the design (Baird et al., 2000). Early in the design process there is a need

for junior designers to obtain clarification on pertinent issues form senior engineers. This interaction between experienced and novice design team members is critical.

8.2.4 Communication

Within Baird's study of collaborative engineering design some interesting communication processes were identified. An ability to build interpersonal relationships in an engineering team can be a slow process in terms of when a junior engineer has the privilege to interrupt a senior, termed 'permissions'. However, in the distributed team this process is yet again more slow (Baird et al., 2000). Depending on the relationship, a design engineer may need to contact another engineer regarding a necessary task but may delay this communication until the task is "…urgent and unavoidable" (Baird et al., 2000). In Baird et al's (2000) findings it was suggested that the virtual environment may not foster skills such as feedback to enable necessary communication between members. If an intranet is used within a design organisation the links between members should be mixed so as to strengthen weak social connections to provide more clear communication channels.

Within the engineering domain communication about design or design processes can be slow to filter out to those not in the exclusive design team (Baird et al., 2000). This can be due to the method of dialogue used; usually late formal rather than early informal, implicating the need for communication early in the design process. This could be a result of team member's lack of experience of working with others. Williams and Cowdroy (2002) highlight the findings that using analogies is easier in the early stages of design if team members have previously worked together.

8.2.4.1 Non-verbal Communication

In Baird et al's (2000) engineering examples, senior engineers are referred to as 'consultant engineers'. Skills in communication, particularly non-verbal, were important for consulting engineers providing feedback to juniors on their suggestions including smiles, nods and frowns (Baird et al., 2000). An ability to utilise these non-verbal cues would be severely impaired in the virtual environment. As yet it is unclear whether video media or use of extremely rich and detailed language could convey these cues in a virtual environment.

8.2.5 Interpersonal Relationships

The way in which team members collaborate during the early stages of design can impact on a team's ability to form a satisfactory product. Social collaboration appears to play an important part in the design process especially when researching and determining limitations in the early design processes.

8.2.6 Team skills

As suggested in section 7.2.1 trust is not easily created in a computer mediated environment, especially when team members have had no prior experience with other members (Jarvenpaa and Liedner, 1998). What is suggested is that the early stages of a design project are conducted in a co-located setting until trust is formed. Virtual teaming may then begin (Jarvenpaa and Liedner, 1998). If this is not possible it is suggested that 'swift trust' is "...maintained by a highly active, proactive, enthusiastic, generative style of action". The commitment of others to the project fosters trust, but this trust may not reach its highest level until the end of the project (Jarvenpaa and Liedner, 1998). A leader who defines clearly the roles for each team member enables the foundations of trust to be formed (Jarvenpaa and Liedner, 1998).

8.3 Technology Facilitators

Technology has been seen as a major facilitator of virtual teams (Perry and Sanderson, 1998). Example of technology include such tools as (Perry and Sanderson, 1998):

- shared whiteboards
- shared editors
- video conferencing
- intelligent agents for conflict detection
- virtual meeting rooms

When utilising a virtual environment it has been suggested by Gay and Lentini (1995) that the use of multiple channels in design, such as video conferencing, a chat box and a drawing tool, will lead to a greater depth and breadth in communication, and also provide back up systems should one channel fail (Gay and Lentini, 1995, Kayworth and Leidner, 2000). In terms of problem solving however, other research has indicated that multiple channels provide minimal or no advantage (Chapanis, 1975). In fact Chapanis (1975), who was one of the first to investigate virtual interaction, highlighted that restricting the channels had little effect on an ability to problem solve, only on the communication process (Maziloglou et al, 1996; as cited in (Gabriel and Maher, 1999, Maher et al., 1998).

9. Discussion

Environmental and technological changes have impacted upon the way in which teams in the construction industry function. A major driver of environmental change has been a move towards more collaborative contractual arrangements, such as alliancing and partnering, which, in turn, promotes technological change. Longer term relationships between project team participants act as a driver for the uptake of new technologies. Investing time and money in new computer hardware and software is more attractive if such technologies can be used on many projects, and with the same people.

With regard to the nature of teams, technology (i.e. cost of technology, speed of information transfer and the associated costs) is, again, promoting moves from co-located to more virtual team activities. However, the challenge of such a move is to incorporate aspects of co-location, such as seeing people whilst interacting with them and an ability to collaborate on issues such as developing an aspect of a design, within a virtual environment.

Generic skills are defined as the knowledge, skills, and attitudes that a team member possesses which support their team activity when completing a task or communicating with others. From a broad base of teamwork research a list of core individual and team skills have been examined within a virtual framework. Problems exist in the transfer of information, and the abilities to utilise these skills, in a virtual team context, and are generally centred on team members' abilities to communicate utilizing these skills. For example, when someone attempts to give feedback in a virtual team they can be limited by the level of communication dictated by the virtual technology. The main area for concern for virtual teams is the ability to communicate, especially non-verbal communication which is more difficult in the majority of virtual communications. The impact of this limitation of skills is most prevalent in relation to team management, feedback and trust.

The study of design teams in the process of designing provides a great deal of information concerning the types of activities which a team and its members undertake. Previous research has identified a range of issues which will inhibit a team's effectiveness in attaining a successful design outcome. The management of a design teams has been defined by the range of management skills which are required to maintain the effectiveness of a design team. The utilisation of virtual environments will introduce a new set of issues which must be confronted by design teams and their individual members.

To be effective design team participants and designers in the virtual environment, designers will require a skill set that extends beyond specific design skills. The skills required to manage teams working in the virtual environment will also need reconsideration if they are to be contextualized in the virtual environment. There currently exists a need to better understand the core skills required by virtual design teams.

A summary of different activities, skills classifications and profiles, relevant to the research context, and which have been identified from literature reviewed in this report, is shown in Table 9 below:

Table 9 Summary of activity, skills classifications and profiles

Design Activities	**Teamwork Core Skills**	**Project Management Skills**	**Virtual Team Skills**
Orientating	Adaptability	Leadership	Trust
Subdividing the problem	Shared situational awareness	Communication	Culture
Establishing roles	Performance monitoring and feedback	Conflict resolution	Archiving
Information seeking	Leadership / team management	Negotiation	
Information sharing	Interpersonal relations	Listening	
Monitoring	Co-ordination	Team building	
Negotiating / understanding	Communication	Relationship management	
Designing	Decision making	Planning	
Building		Contract management	
Evaluating		Problem solving	

The above classifications and issues will form the basis of the next phase of the research: the development of a framework for the analysis of team design activity.

10. CONCLUSION

Teamwork, and development of teams, is a process consisting of a number of stages. Principally the stages begin when team members come together to define a project, followed by a period of action concerning the available design solutions. Next the design solution is chosen and the actual physical artifact is created. The final stage concerns feedback and maintenance of the physical artifact based on team members recommendations. These stages have typically been utilised by the construction industry in the form of the 'generic construction model of the stages of a project team lifecycle' as described by Cornick and Mather (1999). The 'Generic Design and Construction Process Protocol' (Thorpe, 2004) illustrates that construction is a segmented phenomenon, consisting of a series stages that lead to the creation of a successful project outcome. Examination of the stages involved in the design process suggests that 'design' may also be controlled by a protocol providing a map of the design process.

Virtual teaming allows collaboration between team members from remote locations. This has become more prevalent as organisations and industrial alliances become increasingly globalised. The utilisation of virtual teams ultimately leads to an increased turnover of project team lifecycle as travel and costs are reduced. While virtual teams are an effective method of collaboration, given the appropriate project context, they should be approached with caution, especially if one attempts to generalise the skills and methods required by team members from different professional disciplines. A significant criticism of virtual technologies is the effect which they can have on team members' communication channels. It is difficult to utilise those skills examined in section 7 of this report, without the use of non-verbal communication skills, i.e. trust and assertiveness, which are likely to have a minimal impact if conveyed through a typed medium such as email. However, despite having shortcomings, virtual technologies used for collaboration have become more of a necessity in the construction industry.

With regard to the impact of virtual teaming on the early design stages of construction projects, a likely outcome appears to be a more efficient process, encapsulated by more 'right first time decisions', which should lead to an 'improved' final product. However, caution should be exercised when using virtual technologies in the early design phase. If only virtual methods have been used from day one there will be issues with trust. Team members gain a higher level of trust for each other if early interactions are co-located. The lack of non-verbal communication, with some computer technologies, can be daunting during early stages of team development. In addition the lower level of guidance that a junior member can receive in a virtual team may be an issue which could be detrimental to a team's performance.

To function efficiently and effectively in a team environment, irrespective of whether it is a traditional or virtual team, team participants require 'appropriate skills' (i.e. awareness, understanding, abilities to apply). One cannot '*assume*' that all team members automatically possess all of the necessary skills. Previous research has identified that the introduction of new technologies can impact, both positively and negatively, upon the performance of teams. Therefore the ability to map and measure the skills of individuals and teams, leading to training in any deficient areas identified, is seen as critical. The development of skills mapping and measurement tools will be the major outcome of this aspect of our research project. The next phase of the project will take the first of a series of steps by developing a framework for the analysis of design team activities, categorising activities and skills.

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Established and supported under the Australian Government's Cooperative Research Centres Program