Barriers Virtual Design Team Knowledge Sharing

Light. Zaglago, Craig. Chapman, and Hanifa Shah, *Member, IAENG*

***Abstract*—**Globalization is a concern currently affecting many design organizations and is one that has profound implications especially in knowledge sharing.

Companies are gradually turning to virtual design teams as way of bringing both skills and expertise to bear on specific design problems. The idea of an engineering design team as a closely knit, physically co-located team is rapidly dissolving as companies are realizing the Virtual Enterprise vision, where product development projects essentially require resources that are not easily found within a single company. Virtual teams are an increasingly prevalent form of work structures in the 21st century but the challenges have become more pronounced in virtual environments. Virtual team holds the promise of significant benefit. However, this promise will be realized only if all artificial barriers are eliminated to the full benefit. This study aims to investigate the barriers to virtual design team knowledge sharing. This review provides more insight to managers and design engineers on the barriers affecting knowledge sharing and offers directions for enhancement.

***Index Terms*—Knowledge sharing, virtual team, design team**

I. INTRODUCTION

The internationalised context to which design engineer have to work, places further strains on the way a team works as they not only have to cope with geographical distance, but also time, culture and possibly language differences.

Many organisations now have to deal with the increasing internationalisation of business that forces cooperation and knowledge sharing across both time and distance. There is now an urgent need for new ways of sharing knowledge in the virtual team (Kimble *et al.*, 2001).Virtual teams are becoming a preferred mechanism for harnessing, integrating, and applying knowledge that is distributed across design teams and in pockets of collaborative networks (Alavi and Tiwana, 2002).Stough *et al*. (2000) observe that virtual teams, for example, present a new way of organizing global workforces to harness information age opportunity for mobilizing hidden manpower. Holton (2001) reports that identifying and applying appropriate team building strategies for a virtual environment will not only enhance design team effectiveness but will also positively impact the quality of working life for virtual team members (Mohamed *et al*., 2004). By linking individual engineers with different and corresponding skills enhance design knowledge sharing in virtual design teams (Liu and Phillips, 2011).It also adds up to virtual team success by encouraging more efficient use of team resources while decreasing operation errors. Virtual design teams skilled at knowledge sharing should expect increased interconnection and fulfilment among team members(Rosen *et al*.,2007). A well-developed virtual design teams to work more efficiently by sharing cognitive labour. In particular, as team members interact, they may develop insights into the unique skills and special expertise held by their colleagues (Rosen *et al*., 2007).Learning ‘‘who knows what’’ gives members the opportunity to access the individual customized knowledge repositories held by each team member. Thus, individual team members need not be experts on every important team-related issue; they only have to understand who on the team has the expert knowledge needed to answer an inquiry or who can direct them to other sources with the desired knowledge (Rosen *et al*., 2007).Virtual team formation may significantly reduce design team costs of doing business. Evidence showed that expenses associated with travel, varied daily allowances, and accommodation may be reduced or eliminated as virtual teams communicate through the use of technology (Baskerville & Nandhakumar, 2007). For instance, IBM estimated a $50 million saving in travel and downtime costs through the use of virtual teams (Odiwe, 2009). A further advantage of virtual communication is that electronic communication records are retained and archives can be accessed to monitor team activities, review team performance, and evaluate member contribution (Martins *et al.*, 2004). These advantages facilitate better knowledge acquisition and integration (Odiwe, 2009). Hunsaker and Hunsaker (2008) noted that virtual teams enable design teams to find the most qualified individuals for a particular job, regardless of their location.Virtual teams allows design teams to have a faster response time to give them a competitive advantage and provide greater flexibility to individuals working from home or on the road.

A potential advantage of virtual design teams is their

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Light Zaglago is with the Birmingham City University , Faculty of Technology, Engineering and the Environment, City Centre Campus, Millennium Point-Level 4 Curson Street, Birmingham,B4 7XG, England, phone:01952299901 ; fax: 019522999091; e-mail: Light.zaglago@bcu.ac.uk).

Craig Chapman, Professor of Knowledge based Engineering, associate Head of Faculty of Technology, Engineering and the Environment, City Centre Campus, Millennium Point-Level 4 Curson Street, Birmingham,B4 7XG, England (e-mail: Craig.Chapman@bcu.ac.uk).

Hanifa Shah, Research Dean with the Birmingham City University , Faculty of Technology, Engineering and the Environment, City Centre Campus, Millennium Point-Level 4 Curson Street, Birmingham,B4 7XG, England (e-mail: Hanifa Shah@bcu.ac.uk).

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ability to digitally or electronically unite experts in highly specialized fields working at great distances from each other. Thus, virtual design teams that can overcome the perceived risks in sharing member knowledge and develop effective knowledge sharing strategies should better leverage their collective expertise of virtual design teams (Shen and Barthes, 1997). The concept of the virtual team is not clearly defined and it often overlaps with concepts such as the virtual or networked organisations, the virtual workplace, virtual communities, electronic commerce and some forms of teleworking. An essential aspect of virtual design teams is their ability to exploit the features of this new electronic environment. Numerous studies have been carried out on the geography of the information economy one of the main conclusions is that to understand the new spatial dynamics of corporate activities we need to shift our focus from the geography of space and place to the geography of flows. Technology allows information to be accessed from, or transmitted to, remote locations instantly. The information economy, organisations increasingly have to operate in two spaces simultaneously the physical space and the electronic space. These two spaces are not mutually exclusive and they sometimes overlap with each other. However, many of the rules governing these two spaces are fundamentally different. To survive in the information economy organisations must not only exploit geographical differences and overcome geographical constraints in the physical world, but they also have to exploit opportunities and face threats in the new electronic space. Work in global virtual team's places demands on both physical and virtual environments that support these geographically dispersed teams with regard to collaboration, communication and coordination. With longer distances between design engineers, many of them with different responsibilities and activities within design team, the members of the design team need to communicate efficiently despite the challenges that come with collaborating in a geographically distributed work environment.

Geographically dispersed, cross-functional teams are increasingly espoused for enhancing learning and innovation. Cross-functional teams that successfully draw on the diverse funds of design knowledge of members from different intellectual backgrounds are expected to be more creative. By leveraging team members' different perspectives and their access to different sources of information, such teams should be more effective. The participation of dispersed design knowledgeable resources, in particular, is additionally expected to facilitate understanding (Sole and Applegate, 2000).

Telecommunications technology has created new opportunities to train design engineers by transferring design knowledge in a fast and efficient manner. To facilitate design knowledge sharing among existing and newly recruited design engineers. New electronic means of communication are helping design team to break down old cultural barriers and promote closer working relationships among virtual of design engineers with similar duties and skills around the world (Janhonen and Johanson, 2011). By incorporating the core knowledge of a design team, information technology can enhance the transformation of knowledge into action, and help design engineers to effectively share and integrate their knowledge (Li and Jhang-Li, 2010).

Product design is a collaborative effort among different engineering disciplines that typically evolves through knowledge sharing (Sainter *et al.,* 2000).Virtual teams engage in design knowledge work of various kinds, including the development of new products, policies, processes, or services. Teams that develop high-quality design knowledge sharing mechanisms and a more robust design knowledge repository are more likely to accomplish these tasks efficiently and productively (Marino and Chemaly, 2002). Thus, it is important to identify the barriers to design knowledge sharing that might arise in virtual teams (Rosen *et al.,* 2007). Researchers on virtual work have recorded the myriad challenges faced by teams. Some researchers even suggested further that geographic distance among team members had a potential to bear adverse consequences to team performance. Hinds and Weisb (2003) found that frequent challenges faced by virtual teams

The review of virtual team literature suggested that empirical research on virtual teams remains limited in scope, offers few comparable findings, and leaves varied aspects of virtual team start up and functioning uninvestigated (Martins *et al.,* 2004). New research is needed to understand the problems faced by virtual design teams if they are to achieve their full potential in knowledge sharing.

II. RESEARCH METHODOLOGY

This paper is based on a systematic literature review, conducted on journal papers, conference papers, and books on knowledge management, human resource management, technology management, and information management particularly focusing on key themes such as barriers, knowledge sharing and virtual team. These themes were used as key words is searching for related journal articles, conference papers and books from electronic online repositories. The review first examined literature on virtual team and knowledge sharing and then focused barriers to knowledge sharing among virtual design teams.

III. FACTORS AFFECTING VITRUAL TEAM IN KNOWLEDGE SHARING

1,Failure in Sharing and Retaining Contextual Knowledge: Since members of a virtual team are dispersed across multiple locations. Therefore, the work context of individual team members varies along several dimensions, including design team climate and culture, physical layout, competing work demands, and access to information and technology. In collocated teams, contextual knowledge is typically shared and understood through direct observation and shared experience. In face to face environments, visiting team members' offices, attending the same meetings,

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working in the same location, and experiencing the same or similar design team culture and environment all contribute to a shared understanding of the team's context. In virtual team settings, contextual knowledge seems to be held uniquely and tends to be unevenly distributed among team members. Virtual environments neither possess the mechanisms to accurately communicate the context. Failure to share and remember contextual knowledge in virtual team environments may lead to misunderstandings or misinterpretation of a remote team member's behaviour. Unless enabling information technology can provide mechanisms for maintaining the context of dis-course, messages of disproportionately higher complexity must be exchanged to coordinate even the simplest of actions (Li *et al.,* 2005). Differences in perspectives, priorities, typical approaches to problem solving, and even terminology, present among different functional units can hinder understanding of the team. "Interpretive barriers" may be reduced through team members engaging in highly interactive and iterative exchanges,(Sole and Applegate, 2000).Diverse knowledge derived from specific social or physical contexts also hinders design knowledge sharing across situated nature of knowledge present significant problems when sharing design knowledge among dispersed work settings. Collective knowledge also develops through repetitive collective action and resides in systemic routines or ways of interacting such collective design knowledge is "expressed in regularities by which members cooperate in a social team". Implicit shared meanings become associated with particular behaviour within the team, facilitating efficient and effective communications. These associated meanings are learned over time and are, therefore, unlikely to be shared by dispersed team members who haven't previously interacted (Connelly and Kelloway, 2003).

2, Time: The notion of time is significantly affected by the emergence of the electronic space. An important dimension of the industrialisation process has been the standardisation of time in our work and social life. By changing the nature of the technology of distance, the question of time and its significance in our work and everyday life is also reopened. Virtual design teams can pass work-in-progress around the clock among the three main economic centres. Even in the same time zone, work-in-progress can be suspended in time (stored) which gives virtual team members the chance to organise individual time more effectively (Rosen *et al.,* 2007).

Sharing information takes time. Time differences make it difficult when working across time zones and work schedules. Working in virtual design teams poses problems not usually encountered when teams of people work in the same building. Examples include the constraints (and advantages) of time zones. Team members often need to share work-in-progress with others, which may require team members to adopt new attitudes.

3 Overload: Asynchronous technologies enable team members to work ''any time, any place,'' seemingly alleviating time constraints. However, the same technologies can potentially create information overload any time, any place. It takes time to share and absorb knowledge, particularly technical knowledge, from teammates. The amount of cognitive effort that team members are willing and able to spend processing and responding to the information they receive may be limited. Heavy demands from local managers for contributions to local work frequently exacerbate this problem, reducing the time available to share knowledge with and to learn from teammates.

4, Lack of physical world: Although in the electronic space the technology of distance has been eroded other technology of distance derived from differences between places will continue to work. However, the new information age also creates a tension (Rosen *et al.,* 2007). There are some important implications of this face to face element for distributed team working. The members may felt that meetings in the physical world allowed them to get to know each other far better than electronic meetings. The importance of having a good personal relationship with the other members was regarded as essential by all of the members, as this carried the team through the periods of electronic communication. The members gained a greater feeling of identity and common purpose through knowing each other (Rosen *et al.,* 2007).Face-to-face meetings permit team members to learn first-hand about their teammates' backgrounds, experience, and expertise. Team members introduced themselves by giving a brief history of their experiences. Team members also described their professional affiliations and links with other external information sources (Rosen *et al.,* 2007).

Potential problem is the low frequency and unequal spread of interaction between team members, thus impeding full profit from each design engineer's personal qualities and expertise. Problem that may occur is 'flaming', personal conflict technologies and enduring misunderstandings between design team members (Rusman *et al.,* 2010). Team members at remote locations feel left out.Virtual design teams that have not met face-to-face and do not feel like a ''real'' team. It may be difficult to pick up the phone and informally talk with someone when you've never met before face-to-face.

While expertise is "owned" at the individual level, it is necessary to integrate individually held knowledge into team knowledge. The advantage of team knowledge emerges from new knowledge which results from interactions among team members, not simply from individual gains in knowledge by single team members. Individual engineers in the team must integrate their knowledge that is shared at the team level to realize its value. The shared knowledge, coming from individual design engineers, is accessible and sustained through interaction (Friesl *et al.,* 2011).Working in a distributed environment will affect virtual design teams in that they will lose opportunities for informal collaboration and knowledge sharing (Liu and Phillips, 2011).

5. Culture: The different countries and cultural backgrounds that team members came from increased the complexity of global virtual teams (Odiwe, 2009).The diversity of such global virtual team's presents a problematic situation where "different members within different object worlds with different competencies, responsibilities and interests speak different languages.

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There are varying levels of experience. Sometimes assumptions may be made that design engineer shares the same background and that we speak from that shared background. Team members from different countries may have different expectations for how and when work would be completed. Team members from certain cultures may be hesitant to share ideas and to provide constructive feedback of others' ideas. Building sensitivity to cultural diversity is critical to knowledge sharing in global virtual teams (Rosen *et al*., 2007).

6. Understanding of the Domain: A crucial concern for distributed design teams is to successfully deal with the process of reaching a shared understanding of the domain, the requirements, the object of work, the design process itself and the roles and commitments of team members. Design collaboration is framed by the social world, and it is therefore impossible to independently interpret the nature of design specifications and artifacts descriptions without understanding the social situation in which they were created. Since design involves communication and interaction between individuals and teams in complex social settings, the social character of design activity is not separated from the technical. The process of collaborative sense making is critical to successful design, and it also points to the importance of preserving all impact the collaborative design process in one way or another emphasizes that common ground is continually built and rebuilt through the moment-to-moment interactions of team members. Such interactions can be found in many different forms. With reference to design as being a social activity, successful collaboration requires the establishment of a shared understanding, or common ground, between team members. Visual communication that influence social interaction: "In normal face to-face interaction, the members exchange in addition to the information brought forward during collaborative design activities expression, direction of gaze, posture, dress and physical distance" Making sense of design collaboration means that common ground must be achieved with respect to the relevance and meaning of the verbal material, a range of non-verbal cues such as facial though members in design may share a common language, such of global collaboration between diverse work teams the notion of a common vocabulary of design is very appealing (Larsson, 2003).

7 ,Identity: The issues of identity are crucial for the effective formation and functioning of virtual team. Identity plays a critical role in communication where knowing the identity of those with whom you communicate is essential for understanding team interactions Yet, when team members are separated by spatial and temporal borders, identity is ambiguous. Many of the basic cues about personality and social roles that we are accustomed to in the physical world are absent.

In the physical world, there is an inherent unity to the self. The body provides a convenient definition of identity: the norm is one body, one identity. Though the self may be complex and variable over time, the body provides a stabilising anchor. One can have as many electronic personas as one has time and energy to create (Janhonen and Johanson, 2011).

8, Trust: Among virtual teams, trust is very fragile and temporal, and is further dependent upon the communication behaviour of team members. Trust is not constant and often changes over time and easily damaged. In the context of virtual design team, members voluntarily contribute their knowledge without receiving monetary rewards. Unlike traditional design team, membership in virtual design team is open and members of virtual design team are formed by common interests and practices without shared norms and routines to serve as linkage between members and virtual design team. Julibert (2008). Thus, the relationship between members and virtual design team may be more fragile than that of traditional design team (Janhonen and Johanson, 2011). Moreover, most members in virtual design team are relatively invisible, and most virtual design team do not provide guarantees that others will behave as they are expected to the lack of face-to-face communication and legal guarantees makes it harder for members of virtual design team to share their knowledge (Jiacheng *et al*., 2010). There may be lack of trust among team members, making cooperation and collaboration difficult at in newly formed teams(Rosen *et al.,* 2007).When little or no trust exists within a team, serious collaboration problems may occur, such as poor decision-making, hampered information exchange, an increased risk of misunderstandings and mounting personal conflict (Bell DeTienne *et al.,* 2004).

The lack of trust may make it difficult to build team rapport across virtual space.Difficulty knowing the emotions of others through e-mail. No one is quite sure about the passion of members for particular issues. The opinion of Zacaro and Bader (2003) was that the development and maintenance of trust might be one of the most important factors contributing to an overall virtual team success. The consequence of this phenomenon is that trust can be difficult to gain and easy to lose in virtual teams (Gibson & Manual, 2003). Virtual teams with members from different national or cultural backgrounds may face additional challenges in forming trusting relationships (Odiwe, 2009).Asking for information and sharing information with teammates can be risky. Without the ability to observe reactions of virtual teammates to requests for information, virtual team members may fear that such requests might be seen as indicators of incompetence(Rosen *et al.,* 2007).Similarly, sharing unsolicited information or knowledge with virtual teammates may be perceived as grandstanding. There are prospective risks to team members for sharing design knowledge. There is the likelihood of providing incorrect knowledge and suffering the embarrassment and/ or subsequent loss of credibility among one's virtual teammates. When design team members feel that their contributions to the team task may be unfairly scrutinized, they may limit the specialized knowledge they share, focusing only on common knowledge (Rosen *et al.*, 2007).

9, Information Flow Pace: Research indicates that in virtual design teams, which use technology as their dominant means of communication often develops more slowly than in face- to-face. Many virtual design teams may find collaboration problematic. There are several problems that may be encountered. Communication may not be spread

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equally in time. Team members often communicate sporadically in the initial phases of the design but, when facing the 'deadline', can become technology of communication overload. Design engineers may just be exchanging bits of information without building on each other's design knowledge, thus failing to take their design team to the level of collaborative design knowledge construction.

10.Technology: Difficulty projecting our intended meaning through electronic communication. Waiting for clarification wasted a lot of time. Team members were reluctant to interrupt others and many good ideas may be lost (Rosen *et al.,* 2007). The lag between technology and voice proved distracting. Web site that could have been valuable, but getting team- mates to use it consistently may be challenged. Most design engineers reverted to old habits and sent e-mails with long attachments. Outmoded technology also hinders design knowledge sharing in virtual teams (Rosen *et al.,* 2007). Technology problems (e.g., data do not cycle through to different servers; files are not delivered due to size limits; data are stored improperly or in a different format). Electronic communications are not always clear and often require verbal follow-up. It is sometimes difficult to project the proper meaning or intent via e-mail(Odiwe, 2009).Researchers found that proper technology selection and the use of technology for teamwork significantly and positively affects the quality of the virtual teaming process (Carabajal, LaPointe, & Gunawardena, 2003). With the variety of technologies available to virtual teams, the identification of the technologies that fit firm objectives have the potential to improve design team performance (Duarte & Snyder, 2006). A lack of technical expertise and the inability to cope with technical problems have a negative effect on individual satisfaction with the team experience and performance (Kayworth & Leidner, 2000). Evidence demonstrated that virtual team members are affected more by the newness of the technology being used than by the newness of the team structure itself. Edwards and Wilson (2004) noted that technology-enabled virtual teaming would not allow the benefits of virtual team working to be fully exploited unless the company's processes were re-aligned with the capabilities of virtual teams (Odiwe, 2009).

11. Tacit knowledge: Over-emphasizing explicit knowledge, especially through technology investments, makes explicit knowledge more available and may shift emphasis away from relatively tacit components that require face-to-face communication. This process lessens the focus on developing tacit knowledge that has greater strategic significance. Although tacit knowledge can be codified, encouraging and facilitating some direct interactions among virtual team members are beneficial (Martins *et al*., 2004). Face-to-face communication enables team members to observe nonverbal cues and provide synchronous feedback. Ganesan, Malter, and Rindfleisch (2005) found that the richer modality of face-to-face communication encourages the acquisition of tacit knowledge more than electronic communication (Odiwe, 2009). Tacit knowledge can be successfully shared if the frequency of interaction and closeness is high (Larsson, 2003). Key elements in knowledge sharing are not only the hardware and software, but also the ability and willingness of team members to actively participate in the knowledge sharing process (Janhonen and Johanson, 2011).

12. Leaders failed to insure that everyone was ''on the same page.'' The designated team captain became unwilling to listen to members' suggestions.Lack of management/leadership support for any reflection on how we work together. Team leader had a philosophy that ''everyone should be able to do anything,'' so individual talents, backgrounds, and strengths were not typically considered or leveraged. Team leaders have the prerogative of referring to goals on a frequent basis to induce virtual team members to stay on course in the pursuit of their team goals (Nesbitt & Bagley-Woodward, 2006). The possibility for undisciplined behaviour together with poor individual or team performance is viable when teams lose sight of their goals. Forester, Thomas, and Pinto (2007) suggested that the more dispersed the team, the clearer the goals must be because the opportunities for a team leader to be on site to direct team members is greatly reduced(Odiwe, 2009).Leadership challenges increase in a virtual environment (Pauleen, 2004). According to Pauleen, face-to-face meetings should be encouraged occasionally in order for design team leaders to build close relationships with team members at the beginning of a virtual working relationship. Strong relational links are associated with trust, creativity, motivation, morale, good decisions, and fewer process losses. Managers have the prerogative of leading high-performing virtual teams without face-to-face meetings. This entails intensive communications to build a coherent identity and hold the team together Majchrzak *et al.* (2004) further observed that leaders of successful virtual teams support daily team members' communication with one another. Further success was achieved by frequent phone conversations between the team leader and individual members. Research by Kirkman *et al.* (2004), on the performance of virtual teams, may have provided a clue for managers attempting to resolve this dilemma. They suggested that periodic face-to-face meetings be held to focus on process improvement, but if this is not feasible," managers need to make extra efforts to empower virtual teams to deal directly and decisively with process improvement issues" (p. 188).Gibson and Cohen (2003) suggested that virtual team leaders have the imperative of engaging team members in openly discussing cultural differences and similarities to help develop communication norms.Geister, Konradt, and Hertel's (2006) cited in (Odiwe, 2009)work suggested the leader of a virtual team must also play a key role in team process feedback to increase team performance, team satisfaction, motivation, and design team gains. Pauleen (2004) stated that the leader of a virtual team must assess team issues, boundaries, policies, resources, and technology (Li and Jhang-Li, 2010).

13. Communication: Virtual teams face challenges in communication that can escalate conflict or present difficulties with team building and timely task completion (Wilson, 2003).Various researchers have recorded what they observed as communication problems in virtual teams. Schuh (2005) stated that collocated teams were twice as

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productive as non-collocated teams. Schuh ascribed the productivity advantages to fluid communication patterns in the collocated teams. Collocated teams communicated in a continuous and impromptu manner, which made it easier to develop common ground for communication. The collocated team was then better able to develop standard procedures or methods for task performance. They also discovered that privileged communication led to more productivity. The attributes of observed communication included greater development of common ground in communication, more precise timing of cues, and easier repair of misunderstanding. Hinds and Kiesler (2004) in their book on distributed work found that communication across distance and cultural differences was often fragmented with gaps and misunderstandings. On a similar note, Herbsleb, Mockus, Finholt, and Grinter (2000) cited in (Odiwe, 2009) surveyed teams at Lucent Technologies. They found that collocated teams in single sites built significantly larger personal networks, enjoyed more useful information from casual conversations with co-workers, and received more timely information about work plans than members of virtual teams receive. Effective communication in virtual teams is critical to strong performance. Effective communication is the basis for developing high performance work strategies and processes. These work strategies and processes are often the result of fluid communication patterns, such as greater ease in casual conversation with co-workers and reduced misunderstanding because of fewer gaps in context (Odiwe, 2009).

IV. CONCLUSION

When virtual design teams face new challenges, members should critically examine and question their competencies and resources for producing the desired output. Management should include the best possible expertise along with adequate resources. To be effective virtual design teams have to develop new ways of sharing knowledge and understanding in the electronic space. To exploit the two spaces and manage the enormous complexity associated with this will be one of the most significant challenges to management in the next decade and the need to be understood in this broad context.

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