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TECHNOLOGY STRATEGIES FOR GLOBALLY DISPERSED CONSTRUCTION TEAMS

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SUMMARY: *Groups of geographically and/or organizationally dispersed members are increasingly being assembled to accomplish a wide range of organizational tasks using a combination of telecommunication and information technologies. The emergence of such technologically savvy globally dispersed teams has also heralded a complex and largely uninvestigated area of interaction practices of such team members. By enabling team interactions via non-traditional media, information technologies have actually expanded and transformed the conventional team interaction space. This paper assesses the impact of team interaction space on perceived team performance using qualitative and quantitative research techniques. To collect qualitative data, interviews were conducted with members from globally dispersed teams from three Global 500 companies. Audio, video and face-to-face team interactions between these team members were observed and analyzed. A survey on team interaction space was administered to the team members to substantiate the research hypotheses with quantitative data. Triangulating the qualitative and quantitative data, significant correlation was discovered between the effectiveness of the team interaction space and perceived team performance. Factor, path and qualitative analysis demonstrated that organization protocols, communication technologies and spatial setup positively affect interaction space effectiveness. The paper introduces team interaction space as a mediating variable to explain the role of technology, organizational processes and spatial setup on perceived team performance. To apply the research findings in industrial settings, the paper develops a team interaction space framework for designing and managing the environment for globally dispersed teams.*

KEYWORDS: *Team Interaction Space, Effectiveness Continuum, Technology, Virtual Teams*

1. INTRODUCTION

The global nature of many Architecture, Engineering and Construction (AEC) projects means that project teams are increasingly being geographically dispersed working across time zones, numerous organizational boundaries and a variety of cultures, using a combination of telecommunication and information technologies. The uniqueness and complexity of large scale construction projects and involvement of multiple stakeholders from multiple organisations, different skill levels and geographical locations make construction communications and collaboration particularly challenging. Thus, success of virtual teams in AEC domain rely not merely on the introduction and adoption of Information and Communication Technologies (ICTs), but also on critically analysing the underlying social and organisational aspects (Rezgui, 2007). This paper highlights how multi-faceted empirical studies were used to assess the impact of team interaction space on perceived team performance using qualitative and quantitative research techniques.

The paper is structured as follows. Section 2 introduces the team interaction space and discusses its key components including organisational processes, spatial set-up and technology. A framework for capturing team interactions in a holistic sense is presented in Section 3. The research methodology used in the current research is discussed in Section 4. Specific examples of the qualitative data collected and the quantitative analysis of survey data during the hypothesis-testing phase are presented is also presented. Finally, Section 5 summarizes the research findings and outlines the lessons learned from the multi-faceted empirical study of globally dispersed teams.

2. TEAM INTERACTION SPACE

Globally dispersed AEC teams are characterized by a considerable amount of interaction that is conducted synchronously and asynchronously using communication technologies. The physical dispersion between team members in location, time, language and culture makes common issues of communications, team interactions, team-building and productivity a significant challenge. It has long been argued that globally dispersed teams interact less effectively than face-to-face groups (e.g. Warkentin et al., 1997). It is suggested that the lack of social cues: Para-verbal (tone, inflection, and volume) and non-verbal (body language such as eye contact, facial expression, and hand gestures) in computer-mediated communications significantly degrades the flow, context, and content of team interactions. Literature review also reveals that interactions among globally dispersed teams differ in several key areas from face-to-face interactions. Researchers frequently observe more equal participation among members of computer supported globally dispersed teams. This equality of participation is attributed to lower status members being less inhibited in computer-mediated interaction environments. In the absence of the interaction context and a failure to develop strong personal relationships, global team interactions also tend to be more focused on task execution and less on social behaviours. It is also seen that in absence of face-to-face interaction, individuals express negative and uninhibited messages during computer-facilitated interactions more freely. Resultantly, very often globally dispersed teams have more difficulty in reaching consensus compared to face-to-face teams because of a lack of interpersonal feedback and reduced concern with social norms.

However, literature review reveals that opinion is divided about the magnitude of the differences between global and face-to-face team interactions. For instance, studies have found that globally dispersed teams may communicate as effectively as face-to-face groups provided they have sufficient time to develop strong relationships and adapt to the use of collaboration technologies (Duarte & Synder, 2006; Nemiro et al., 2008). The dominating issue in developing this team bonding may not necessarily be time. Very often, AEC teams come together for a short period of time not conducive to build team feeling. Thus, the interaction context is usually process-driven. Such distributed AEC teams may not share a common first language or business culture and thus facilitating the interaction space for globally dispersed team members requires all the finesse and skill of facilitating a face-to-face meeting or workshop experience. In order to communicate better it is imperative that virtual teams have efficient communication processes, as they rarely get to meet face-to-face. If team members can work together to develop their own norms or adopt pre-established organizational norms and expectations based on team and organizational values, they can do much to maximize their potential to produce effective results by reducing the possibilities of misunderstanding and conflict. The proper use of technology coupled with organizational support for making team processes effective through emphasis on interaction protocols, leadership, diversity and proper management of resources could play a key role in productive virtual interactions.

The above discussion implies that there are diverse issues related to bridging temporal, cultural, organizational barriers for construction teams to make a successful change from a “local” to a “global” construction environment. The multi-diverse nature of global teams makes the process of collaboration complex and difficult to manage. One of the key issues for globally dispersed teams is therefore to set the bounds of their interaction space (Vadhavkar & Peña-Mora, 2002). The interaction space addresses the key elements of communication, co-location, co-ordination and collaboration and is made up of three key components (Vadhavkar & Pena-Mora, 2002) including organizational processes (e.g. trust building, team culture, meeting processes, team processes and team members' behavior), information technology (e.g. audio/video conferencing systems and computer supported communication processes) and spatial setup (made up of the intersection of physical space comprising of meeting room layouts, office environments, and workspaces with the digital space comprising of collaborative application spaces, team web sites and collaborative software applications) (Figure 1).

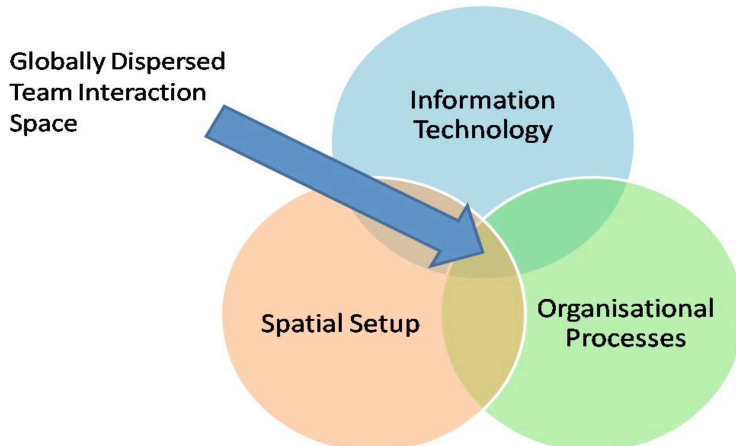

FIG 1: Key components of Virtual Team Interaction Space (Vadhavkar & Pena-Mora, 2002)

3. EFFECTIVENESS FRAMEWORK BASED ON TEAM INTERACTION SPACE

It is hypothesized that globally distributed AEC teams function inside a virtual team interaction framework (Figure 2), which captures interactions in a holistic sense. The interaction framework includes a whole range of activities, from interactions carried out in the interaction space, to observing the barriers to effective interaction in the interaction space comparing them with the desired state, making adjustments to remove these barriers and mapping team performance to a team interaction effectiveness continuum to identify areas of improvement as well as evaluate team's performance. This interaction framework captures the iterative nature of the interaction process and key steps in its application are discussed below:

- Identification of barriers to TIS effectiveness through observation of interactions carried out in the interaction space. This will also indicate deviation from desired state as indicated by effectiveness targets;
- Positioning the team in the TIS effectiveness continuum;
- Evaluation of the revised TIS effectiveness targets after positioning the team on the TIS effectiveness continuum;
- Enhance/provide goals for further interaction in the interaction domain/space;
- Iterate the cycle over time, as the interactions are dynamic and as the framework shows the cycle is repeated over time.

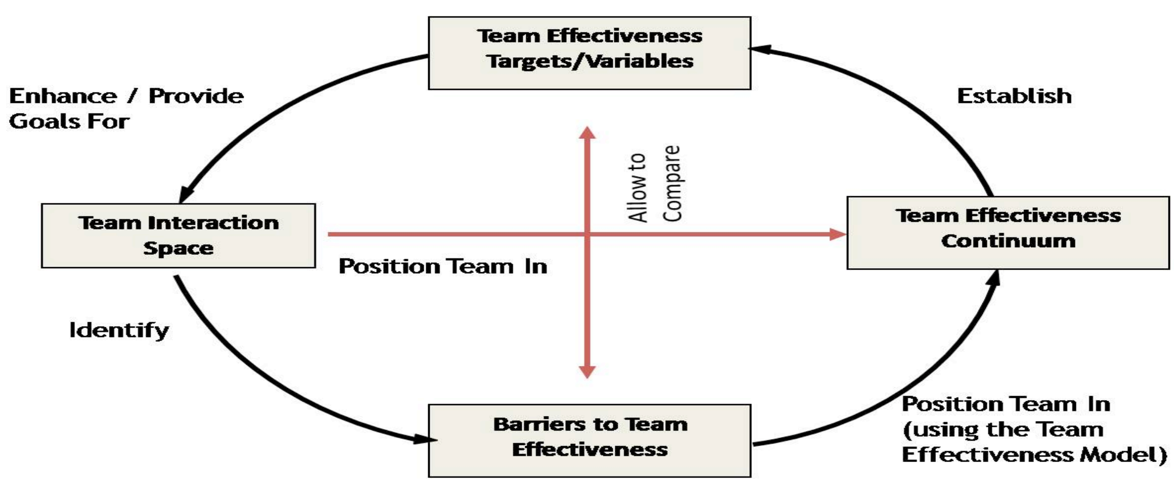

FIG 2: Virtual Team Interaction Framework

The interaction space effectiveness continuum is a spiral curve mirroring the real life growth of a globally dispersed team from its inception, when it could be either just a collection of combative people with conflicting ideas or a collective of individuals trying just to work together, to an optimized group with efficient processes for effective use of the virtual team interaction space (Figure 3). The positioning of the team on the TIS effectiveness continuum is indicative of the health of the TIS and provides useful feedback about how to improve its effectiveness. The TIS effectiveness model uses a number on a scale of ten as indicative of effectiveness. This number will map to a specific evaluation of the team by its positioning on the TIS continuum.A newly formed team can join the spiral curve at any level of proficiency on the TIS effectiveness continuum. Even small deviations in team composition or the environment can move the team up or down the effectiveness continuum. The effectiveness continuum relates the team to effectiveness barriers, which hamper the team from a more effective interaction and prevent them from achieving effectiveness targets that they would expect to achieve as they improve their interaction process over time. The effectiveness targets are indicators of the team interaction performance and are measures/deliverables that the interaction process would have at specific and defined checkpoints. The metrics/checkpoints serve as indicators of what is wrong or what are the barriers to interaction, which need to considered and eliminated. Different stages in the team effectiveness continuum are discussed in Table 1.

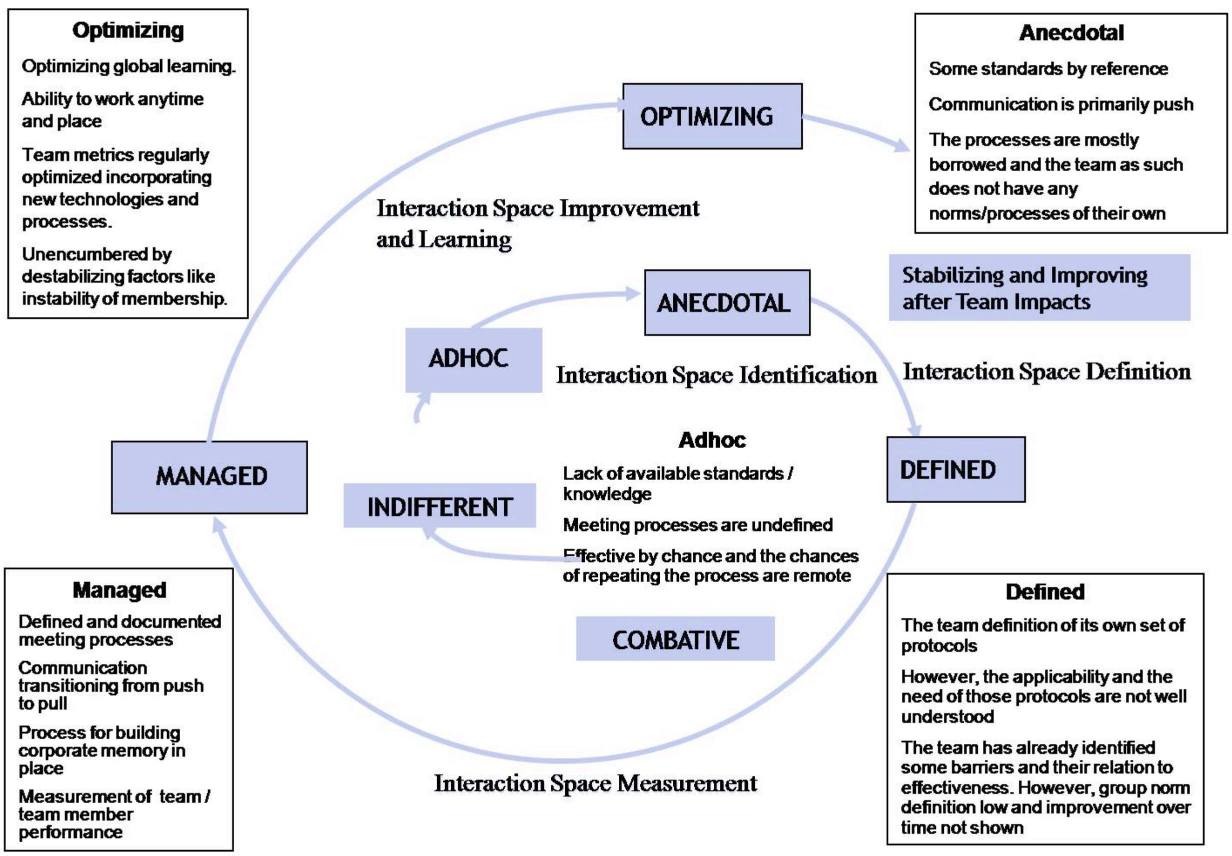

FIG 3: Team Interaction Space Effectiveness Continuum

TABLE 1: Stages in the Team Effectiveness Continuum

Team Development Stage	Description
Combative	• Lack of team alignment • Interpersonal conflict and disregard for others • Technology used as a means to stress the inequalities as a measure of importance
Indifferent	• Total lack of disregard for team issues • Lack of interest in team • Technology misused and stresses the disenchantment of members in the interaction process
Ad-hoc	• No available standards • Interaction processes undefined • Effective by chance and chances of successful replication remote
Anecdotal	• Some standards, mostly borrowed • Communication primarily push
Defined	• Team has its own set of protocols whose applicability and need are not well understood • Team has identified some barriers and their relation to team effectiveness
Managed	• Defined and documented interaction processes • Communication transitioning from push to pull • Infrastructure for building and utilizing corporate memory in place
Optimized	• Improved global learning • Ability to work anyplace and anytime • Team metrics optimized regularly
Stabilization and Improving	• Steady state, which can be impacted by several disturbances thus bringing the team interaction space effectiveness down to any of the above stages

The evaluation of the TIS effectiveness and subsequently positioning the team on the TIS effectiveness continuum is based on evaluating team's activities on a number of different counts. For effective evaluation of TIS effectiveness a collaborative survey was developed as part of this research and a sample of questions is presented in Figure 4.

SECTION D: Team Structure and Processes

Please indicate the degree to which you agree or disagree with each of the following statements about your global team.

	Statement	Strongly Agree	Agree	Agree Somewhat	Neither	Disagree Somewhat	Disagree	Strongly Disagree
1.	All members of the global team agree on the team's goals	1	2	3	4	5	6	7
2.	Team members participate in the decision making process	1	2	3	4	5	6	7
3.	The combination of skills on this global team was carefully chosen to fit the task.	1	2	3	4	5	6	7
4.	Our global team has complementary technical and social skills.	1	2	3	4	5	6	7
5.	Functional skills are the most important factor for choosing global team members.	1	2	3	4	5	6	7
6.	Language is not a barrier to success of global teams.	1	2	3	4	5	6	7
7.	Team members of different countries do not work well together on the team.	1	2	3	4	5	6	7
8.	Most team members in my global team have no experience working in locations with different culture	1	2	3	4	5	6	7
9.	Diversity among people on the global team helps create better solutions	1	2	3	4	5	6	7
10.	Cultural differences hinder global team performance	1	2	3	4	5	6	7
11.	Changes in the team membership negatively impact global team performance effectiveness.	1	2	3	4	5	6	7
12.	Working together over time improves my team's performance	1	2	3	4	5	6	7
13.	The team members trust our team leader to fairly represent our global team needs.	1	2	3	4	5	6	7
14.	The team has the autonomy to select options that the team leader does not endorse	1	2	3	4	5	6	7
15.	The global team has a formal process to help transition new team members into their new role	1	2	3	4	5	6	7
16.	Transition for new members on the global team happens too quickly	1	2	3	4	5	6	7
17.	The team has created norms of appropriate behavior among its members	1	2	3	4	5	6	7
18.	The global team has a mentor who helps the global team in reaching its goals	1	2	3	4	5	6	7
19.	Global team operating procedures and protocols support successful completion of the team's task	1	2	3	4	5	6	7
20.	Success of the team is dependent on the shared contributions of all team members	1	2	3	4	5	6	7
21.	Among the members of the global team, duties are divided equitably	1	2	3	4	5	6	7
22.	Work details are often defined when team members talk with each other	1	2	3	4	5	6	7
23.	Over time the team is creating it's own unique 'history' of stories and ways of doing things	1	2	3	4	5	6	7
24.	Sharing knowledge with my team members is an important part of my work with team	1	2	3	4	5	6	7
25.	My global team shares lessons learned from other teams	1	2	3	4	5	6	7
26.	As the global team continues to work toward a shared goal, the relationships among all the team members are becoming stronger and more important	1	2	3	4	5	6	7
27.	It is hard to trust the other people on the global team because we do not have time to get to know each other	1	2	3	4	5	6	7
28.	Remote team members are less productive than team members from local site	1	2	3	4	5	6	7

FIG 4. Illustration of Questions from Survey

Different variables used for assessing TIS effectiveness are summarized below.

Communication Technologies facilitate interaction between dispersed virtual team members. Key issues related to the use of these technologies include the relevancy of communication technologies in fulfilling team requirements, the capability of these technologies in terms of usability, functionality and reliability, facilitation of team interaction processes by using adequate communication technologies, support for the team in using these technologies and adequacy of the technologies to provide relevant information to the right person at the right time.

Team Interactions include both synchronous and asynchronous modes of communications. Key issues in team interaction processes include the degree of interest in team processes among local and remote team members, the effectiveness of face-to-face and virtual team meetings, capability of global team members in running virtual meetings, the adequacy of the agenda in virtual meetings, reconciliation of local versus global needs, process in which lessons learned are shared and assimilated and task distribution amongst team members.

Individual Perceptions about the team and the organization directly affect the effectiveness of interaction processes carried out by these individuals. Key issues in individual perception include belief in organizational culture, understanding about the team's goals and objectives, trust in local and remote team members, assessment of performance evaluation mechanisms and team member participation in decision-making processes.

Team structure and processes encapsulate most team related issues including cumulative and matching technical and social competencies of team members, the importance of language in team interaction processes, norms for team member behavior, transitioning of global team members on or off the team, mechanisms for knowledge sharing, affect of time differences of remote team members on team bonding and interaction and information flow mechanisms from team members to team leaders.

Team/organizational outcomes Globally distributed virtual teams in AEC sector are usually brought together for a specific project to achieve a particular goal. Key issues include agility in decision-making, team performance evaluation in terms of deliverables, relative improvement of technical skills after participation in global teams, career advancement through global team performance and performance evaluation metrics based on local versus global performance.

Team Support The organization needs a lot of support both in terms of infrastructure as well as high-level support for the team. Key issues in team support include identification of global teams as appreciated/valued by company, performance evaluation and reward processes, local perception about global team processes, sharing lessons from team level to a broader organizational level and strategic level support for global virtual teams.

4. RESEARCH METHODOLOGY

Figure 5 shows the research model used in this research effort. In seeking to understand the experiences of globally dispersed teams, researcher relied on their personal experiences as members of global dispersed teams to create an initial set of broad research objectives. These included:

- To gain a better understanding of collaboration between globally dispersed team members by observing the team interaction space.
- To investigate potential roles of technology, organizational processes and spatial setup on facilitating interactions.
- To obtain a set of basic criteria defining what are effective and efficient collaboration practices for globally dispersed teams.

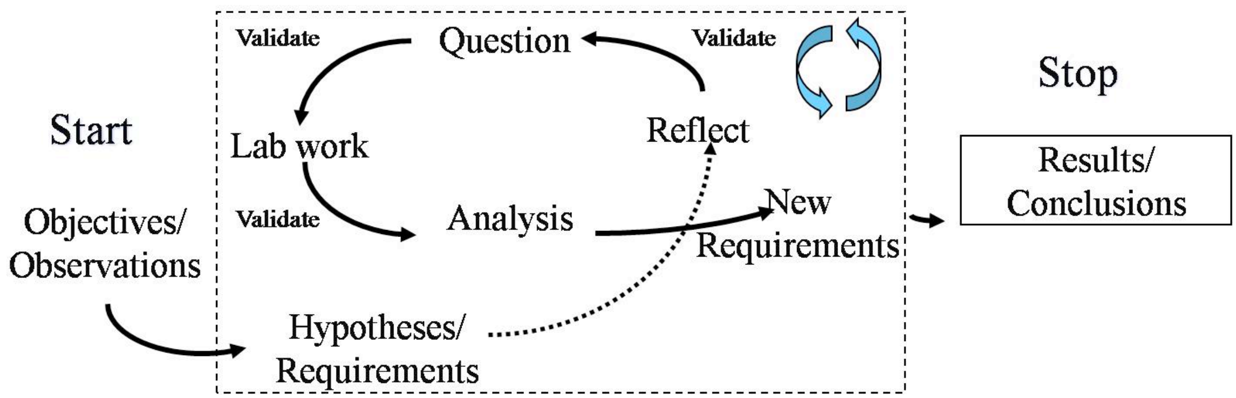

FIG 5: Research Model to Study Interactions of Globally Distributed Virtual Teams

The Objectives/Observations stage included tracking synchronous interactions by observing videoconferences of select globally dispersed teams over a significant interval of time. Other preliminary data on global team interactions was gathered during focus group meetings and discussion forums. In the Reflection stage, observations from the synchronous interactions were presented to team members under study eliciting their feedback. Specific interaction patterns were presented to a wider audience in discussion forums to gather reflections on initial research hypotheses and questions. In the Question stage, surveys and interviews were carried out to collect both quantitative and qualitative data on team interaction space to either substantiate or refute the key hypotheses. Key steps in research method are described in more detail in the following Section.

Research hypothesis was that, "When estimating the impact of communication technologies on the effectiveness of team interaction space, a uni-dimensional approach proposed in the literature is not sufficient to explain the barriers faced by global teams. Instead, technologies used by globally dispersed teams need to be considered in multiple dimensions including ability to use technology, capability of the technology, reliability of the technology, accessibility to the technology and support for the technology. To confirm or refute the hypothesis, techniques used included web-based and Microsoft Excel based surveys for quantitative data analysis, Frequency analysis, Factor Analysis for Creating Scales (using SPSS software) and Correlations (using SPSS software).

TABLE 2: Technology Dimensions and Team Interaction Space Effectiveness

Technology Dimension	Question Number	Question Description
Ability to use the Technology	COM 2	Communication technologies used for communicating synchronously with remote team members are difficult to use
	IND 3	I have yet to master the communication technologies needed to share knowledge with my global team members
Capability of the Technology	COM1	Overall, I am satisfied with the current set of technologies used in communicating with global team members
	COM3	Communication technologies used for communicating with remote team members facilitate effective global team meetings
	COM6	Communication technologies allow me to convey my ideas very effectively to my global team members
	COM13	Communication technologies allow everyone in the team to have access to information needed to get the job done
Reliability of the Technology	COM 7	I use very basic technologies such as phone, email and project web sites to meet my functional needs to collaborate with my global team members
	COM 10	New communication technologies that provide better functionalities do not have to be very reliable before they can be adopted by my global team members
Accessibility to the Technology	COM 9	Communication technologies used by the global team are conveniently accessed from multiple locations (e.g., cubicles, office, meeting room, home, airport)
Support for the Technology	COM 4	I receive sufficient training to use communication technologies most effectively on global teams
	COM 12	The company provides excellent support (e.g., training staff, help desks) for using communication technologies

As a first step in quantitative data analysis, a Factor Analysis was carried out on various items from the questionaiire as described in Table 2. Factor analysis is a generic term that is used to describe a number of methods designed to analyze interrelationships within a set of variables or objects resulting in the construction of a few hypothetical variables or objects, called factors. These factors are supposed to contain the essential information in a larger set of observed variables or objects. By taking advantage of inherent interdependencies, a small number of factors will usually account for approximately the same amount of information as do the much larger set of original observations (Daniel 1989). Factor analysis includes a variety of correlational analyses designed to examine the interrelationships among variables (Carr 1992). Key steps followed included creation of scales for communication technology (Table 3), running reliability analysis for each scale and finding co-relations between items. Kaiser-Meyer-Olkin Measure of Sampling Adequacy for the Team Interaction Space effectiveness scale is 0.788 while the Bartlett's Test of Spehericity shows Chi-Square of 177.425 and significance of 0.000. KMO measure should be greater than 0.5 and Barlett's Test should have low significance value. KMO Measure and Bartlett's Test indicate that the Factor Analysis was fairly adequate and robust. In addition, it can be seen from Table 3 that three Factors together explained a cumulative 51.735% of variance. For factor analyses, the Extraction Method chosen was Principal Axis Factoring followed with Oblimin method with Kaiser Normalization for rotation, since this allows for a single primary factor (together with some residual variation accounted for by other lesser factors); and factors that are correlated (i.e., factor correlations are less than unity and therefore not orthogonal). The factor loadings reported below are derived from the "Pattern" matrices for a three factor solution. After the individual items for each factor were identified, reliability analysis was carried out to determine if the items could be combined as a single factor.

TABLE 3: Factor Analysis for the Communication Technology Scale

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy		**0.788**
Barlett's Test of Sphericity	Approx.Chi-Square	177.425
	df	45
	Sig	**000**

Total Variance Explained			
	Extraction Sums of Square Loadings		
Factor	Total	% of variance	Cumulative %
1	3.810	38.100	38.100
2	0.996	9.962	48.062
3	0.367	3.677	**51.735**
(Extraction Method – Principal Axis Factoring)			

PATTERN MATRIX			
	Factor		
	1	2	3
COM 3	0.901		-0.193
COM 6	0.800		
COM 1	0.708	0.228	
COM 9	0.616		0.212
COM 13	0.451	0.308	0.123
COM 4		1.008	-0.197
COM 12	0.222	0.641	
IND 3		0.290	0.172
COM 10	-0.158		0.483
COM 7	0.123		0.418

Based on the factor analysis, three factors for communication technologies were recommended (Figure 6). Factor 1 signifies capability of communication technology and accessibility to the technologies. Factor 2 pertains to supportiveness of the communication technologies. Factor 3 refers to the reliability of the technologies.

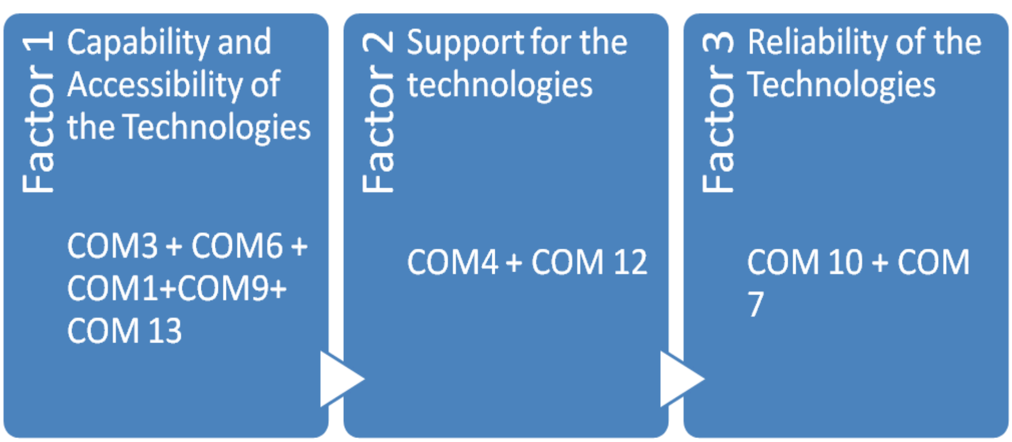

FIG 6: Key Features for Communication Technologies

This substantiates the hypothesis that the impact of communication technologies on the effectiveness of team interaction space needs to be considered in multiple dimensions. Next step involved finding which of the technology dimensions correlate with team interaction space effectiveness.This will help analyze which technology dimensions are more important than others for increasing the effectiveness of the team interaction space. Correlations were computed to study the impact of following technology dimensions on the effectiveness of team interaction space: Technology Ability, Technology Capability, Technology Accessibility, Technology Supportiveness and Technology Reliability. Figure 7 shows the correlations between team interaction space effectiveness and the technology dimensions. As the figure indicates, technology capability, accessibility and supportiveness were strongly correlated to team interaction space effectiveness with Pearson Correlations of 0.413, 0.406 and 0.637 respectively, significant at the 0.01 level. Surprisingly enough, technology ability (ability of team members to use the communication technologies to interact with global team members) was found to be not correlated with team interaction space effectiveness. Technology reliability was correlated with team interaction space effectiveness with a Pearson Correlation of 0.238 significant at the 0.01 level only. This indicates that reliability of technology does not impact team interaction space effectiveness. One possible explanation of this effect could be that team members use basic technologies such as phone, e-mail and project web-sites with very high inherent reliability. Since the technologies have high reliability, the effect of unreliable technologies is not experienced as frequently.

		Interaction Space Effectiveness Scale
Technology Ability	Pearson Correlation	.204
	Sig. (2-tailed)	.069
	Covariance	.103
	N	80
Technology Capability	Pearson Correlation	.588**
	Sig. (2-tailed)	.000
	Covariance	.389
	N	80
Technology Accessibility	Pearson Correlation	.406**
	Sig. (2-tailed)	.000
	Covariance	.432
	N	80
Technology Supportiveness	Pearson Correlation	.637**
	Sig. (2-tailed)	.000
	Covariance	.583
	N	80
Technology Reliability	Pearson Correlation	.238*
	Sig. (2-tailed)	.033
	Covariance	.147
	N	80

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

FIG. 7: Technology Dimensions and Team Interaction Space Effectiveness

4. Discussion and Conclusions

This research conclude that technologies used by globally dispersed construction teams need to be considered in multiple dimensions including ability to use the technology to interact, capability of the technology to support the interaction space, reliability of the technology used for interaction, accessibility to the technology from multiple locations (for example, office, cubicles, meeting rooms, homes, airports) and support provided to use the technology to interact. Research also demonstrates that significant correlation exist between the support provided to use the technologies and effectiveness of the team interaction space. However, research found lesser correlation found between the ability to use the communication technologies and effectiveness of the team interaction space.

Instead of traditional uni-dimensional scale, this research highlighted five significant dimensions of communication technology in team interaction space. This helps to explain the potential impact of communication technologies and certain organizational processes on increasing the perceived team performance. Contrary to conventional wisdom,the research shows that the ability to use the technology seems to have less impact on the interaction space effectiveness. Over 80% of the questionnaire respondents disagreed with the question that they found it difficult to use the communication technologies.

Over 74% of the questionnaire respondents agreed that they had not mastered the technologies to share knowledge with globally dispersed team members. This research also identifies that the support provided by the company to use the technology significantly affects the effectiveness of team interaction space. One plausible explanation for this phenomenon could be that Technology supportiveness helps acceptance of technology use within the interaction space. This research also shows that accessibility to communication technologies is a strongly desired feature amongst global team members (76% of questionnaire respondents agree). Access to communication technologies also strongly correlates with the efectiveness of team interaction space.

In light of this research, it is recommended that construction companies, when introducing new communication technologies for global team members, should look at the following factors:

- Ability to use the technologies
- Capability of the technologies to support interactions
- Reliability of the technologies
- Accessibility to the technologies
- Support that can be provided to use the technologies

Thus, construction companies need to continue providing proactive support for communication technologies making the interaction space more effective. This support could be in the form of help desks or skilled technical assistants/meeting facilitators in the interaction space. Also, companies need to make communication technologies more accessible to global team members to increase the effectiveness of team interaction space.

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