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EXAMINING THE EFFECT OF BOUNDARY SPANNING TECHNOLOGIES IN VIRTUAL PROJECT TEAMS

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Abstract: Overcoming the challenges of virtual collaboration may require different approaches to achieve performance objectives for virtual teams of mixed nationality participants as compared to virtual project teams of single nationality participants. Many researchers have examined the way multinational project participants collaborate in order to sustain effective collaboration across boundaries. However, we lack a similarly nuanced understanding of networks of individuals on project teams comprised of mixed nationality participants that utilize virtual collaboration environments and new information technologies. In this paper, we examine the role of Boundary Spanning Visualization Technologies (BSVTs) to understand differences that may emerge at the cross-national boundary in virtual teams of mixed nationality participants. We found that BSVTs within the virtual workspace were utilized more frequently by virtual teams of mixed nationality participants. We also identified a positive correlation between effective technology usage and cohesive collaboration among project participants measured by network density. These findings have important implications for the effective functioning of multinational project teams that utilize virtual environments in the construction industry.

Keywords: Mixed Nationality Teams; Virtual Teams; Virtual Workspace; Visualization.

1 INTRODUCTION

The construction industry is undergoing a major transformation all around the world. According to the "Global Construction 2020" report published by Global Construction Perspectives and Oxford Economics, construction in emerging markets is expected to double within a decade and will become a $6.7 trillion business by 2020 (Betts et al. 2011). Consequently, more contractors are looking to emerging markets for potential projects, especially given the increase in construction activities in developing countries (Wong et al. 2010). In this competitive environment, construction companies must respond quickly and effectively to changing customer demand. Thus, organizations change their organizational structure in order to meet the demands of the fast-paced, dynamic global economy and they are moving toward a more collaborative structure. The changing market conditions are prompting the formation of multinational collaborations. In the

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construction industry, project teams that are comprised of mixed nationality participants collaborate over geographical, temporal and cultural boundaries. In addition to organizational transformations, there are also important changes and developments in technology that impact how multinational participants collaborate. One of the drivers for the change of collaboration approaches is the introduction of information and communication technologies that have made it easier to collaborate across boundaries (Maznevski and Chudoba 2000). Increasingly, dispersed project participants work remotely by utilizing advanced technology, which leads to virtual collaboration. Researchers have developed an extensive understanding of the way multinational project participants collaborate and the support they need in order to sustain effective collaboration across boundaries (e.g. Di Marco et al 2011). However, we lack a similarly nuanced understanding of project teams comprised of mixed nationality participants that utilize virtual collaboration environments and new information technologies. In this paper, we examine different collaboration approaches developed among multinational project participants in a virtual setting and compare them with teams of single nationality participants.

2 BACKGROUND

2.1 Features of Multinational Virtual Project Teams

In recent years, virtual collaboration—which enables geographically dispersed members to work together in situ—is being implemented in the construction industry. To remain competitive in changing global markets, virtual settings are playing an important role in project work and offer organizations flexibility (Mowshowitz 1997). By utilizing virtual environments, organizations are able to respond faster to increased competition, and provide greater flexibility to individuals working from various locations. Some have argued that teams collaborating using computer mediated communication are as effective as teams working face to face and, under some circumstances, may actually be slightly more effective (Hatem et al. 2012). Yet there are also challenges that organizations may encounter while establishing virtual teams such as building trust, cohesion, and team identity, and overcoming isolation among virtual team members (Kirtman et al. 2002).

While virtual teams provide a great deal of flexibility, the cultural and linguistic diversity among team members can have both advantages and disadvantages (DiStefano and Maznevski 2000, Adler, 2008). According to DiStefano and Maznevski (2000), there are three different types of global teams; the destroyers, the equalizers and the creators. Among them, only the creators value the diversity and perform at high levels since the differences among team members are explicitly recognized and accepted, even nurtured (DiStefano and Maznevski 2000). However, not all multicultural groups belong to the "*creators*" class of global teams. There are also other types of global teams that do not value diversity; "*destroyers*" consider differences as a handicap and "*equalizers*" suppress differences in ideas and perspectives (DiStefano and Maznevski 2000). In unsuccessful multicultural groups, miscommunication, lack of trust, and within-culture conversations (Adler 2008) may create challenges that can be barriers to meeting project objectives. On the other hand, it has been found that after only a few collaborative projects, as multicultural project network members become accustomed to collaborating and develop strategies to overcome the cultural and linguistic barriers, global project networks start to benefit from the diversity and can potentially perform better than domestic project networks (Comu et al 2011). Multicultural project network members may require additional support to overcome initial difficulties and to thus fully benefit from the diversity.

2.2 Boundary Spanning Technologies in Multinational Virtual Project Teams

Considering the enormous amount of information generated and exchanged during the lifecycle of a construction project, sustaining accurate and instantaneous information transfer between dispersed team members through various boundaries is challenging. In general, boundaries refer to the 'physical, temporal, emotional, cognitive, and/or relational limits that define entities as separate from one another' (Ivory et al., 2006: 474). Early seminal work on boundaries by Star and Griesemer (1989) describes the creation and management of boundary objects to be a key process in developing and maintaining coherence between the entities. To cross boundaries, artifacts are needed to fulfill an effective bridging function (Star, 1989). In this respect, many researchers have sought to describe the characteristics of effective boundary objects (e.g. Carlile 2002; Star, 2010). Carlile (2002) identified three characteristics of a tool, method, or object that made them effective at a given boundary. According to Carlile (2002) a boundary object establishes a shared syntax or language for individuals to represent their knowledge which is very crucial to the efficient functioning of a multinational team that has to span various boundaries in a virtual setting.

In this sense, evolving project information formats such as 3D modeling and Building Information Modeling (BIM) which serves as a boundary object make it easier to transfer project data among project participants. Through evolving communication modes, novel project information formats are more practical to transfer. Virtual world technologies allow distributed teams to engage in 3D models and BIMs to gain some of the same benefits as collocated teams. Koutsabasis et al. showed that design activities can be effectively supported in virtual workspaces where users manipulate and arrange 3D models and make changes together in real time (2012). The authors concluded that virtual worlds are a satisfactory collaboration environment for designers because they provide increased communication and awareness. The use of these technological boundary object affordances in virtual worlds has been shown to reduce task conflict in multinational virtual project teams (Iorio and Taylor 2013). In other words, project visualization in a virtual workspace can be utilized as a platform to exchange and communicate information effectively.

3 Research Methodology

3.1 Research Setting

In this research, we aim to develop an understanding of the way multinational project teams collaborate differently than project teams of single nationality in terms of utilizing the BSVTs in the virtual setting. For this reason, we observed and recorded interactions among two teams of mixed nationality and two teams of only US participants collaborating in a virtual workspace over a two-month period. Both types of virtual project team were comprised of sub-teams of graduate students from Columbia University and the University of Washington in Seattle who were studying civil engineering, construction management or architecture, some of whom also had industry experience. Since simulated virtual project teams were studied, the workload of each team was arranged by considering the duration and the experimental setting. Therefore, having two graduate students in each team was deemed adequate to perform the assigned tasks.

In the multinational virtual project teams, all students were from different countries and did not share the same native language and recently started to study in the USA which ensured and controlled for cultural and linguistic diversity in the multicultural project teams. The virtual project teams of single nationality were comprised of only students from the U.S. and all were native English speakers. Students participated in this study as a part of their academic coursework, i.e. working together on the assigned project was their semester assignment. Columbia University students were asked to develop an organizational model utilizing Simvision and students from the University of Washington were asked to develop 4D models using Navisworks.

3.2 Data Collection and Preparation

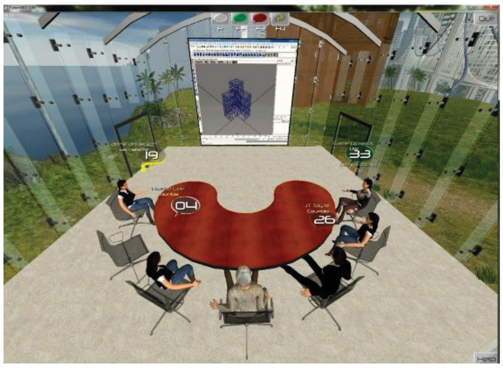

Figure 1: The CyberGRID

During the data collection period, students met in a virtual workspace called the CyberGRID (Cyber-enabled Global Research Infrastructure for Design) (Iorio et al. 2011), once a week for a two and one-half hour period. All the interactions during the virtual meetings were recorded by an automated system built in the CyberGRID. The CyberGRID contains a number of communicative and collaborative features. Voice and text chat were integrated to provide synchronous communication for the virtual project teams. Additionally, document sharing and message board functionalities were integrated to facilitate collaboration on the complex project models. More importantly, the CyberGRID provides BSVT including spatial visualization to achieve effective and clear communication. These spatial visualization technologies that support spanning boundaries in the virtual environment include: 1) an integrated 3D model that students can walk through with their avatar, and 2) a shared visualization screen called the Team Wall on which they can project the models they are designing. The CyberGRID provides a rich communication environment through multiple channels that enable participants to speak, share information, and gesture and span both organizational and cultural boundaries in the virtual work space.

In order to quantify the recorded data, we used a multi-modal open-source annotation software called ELAN to create, edit, visualize and search annotations that we mapped to the video and audio timelines for the recorded interactional data (Wittenburg et al. 2006). Data collection took place over 8 weeks and different tasks were assigned to teams for each week. During the first week, students were given the opportunity to get to know each other through icebreaking activities and received training in the use of the CyberGRID's virtual interactional affordances. The following week, called client meeting week, they were provided with project guidelines from their instructors during a simulated client meeting that took place in the CyberGRID. This meeting conveyed the design requirements of each team that the students needed to construct the organizational and 4D models. During the following four weeks, the participants were expected to complete both models and perform interventions to improve the models. After finalizing the organizational and 4D models, the teams were expected to complete a written report and prepare an oral presentation of their project results. Because our research focus was on the task related information transfer between team members, data from the organizational modeling, 4D modeling, and intervention tasks were chosen for analysis. In total we coded 18,680 interactions for the two virtual project teams of mixed nationality participants (10,526 interactions) and the two virtual project teams of only US participants (8,154 interactions).

4 RESULTS AND DISCUSSION

In this study, we used two types of study groups—multinational and single nationality project teams—and observed their collaboration in a virtual workspace. The collaborative efforts of team members in multinational virtual project teams are likely to result in enhanced creativity, an increased number of innovative ideas, and culturally representative solutions (Zakaria et al., 2004), which make them distinctive from virtual project teams of single nationality participants. However, restricted communication opportunities in virtual settings might prevent the benefits of diversity from being fully realized and instead increase misunderstandings and conflicts. In order to overcome these drawbacks and leverage the advantages of diversity, multinational virtual project team members are likely to need more visual support and references. Because BSVTs allow for the creation of a shared reference and effective communication (Koutsabasis et al. 2012), we expected that they may play an important role in allowing multinational virtual project teams to leverage the benefits of their diversity and overcome the communication difficulties. Specifically, the collaborative technologies are a way through which to improve diverse teams' development processes and performance as the negative aspects of diversity can be reduced by using communication media appropriately (Staples and Zhao, 2006). In this sense, we initially calculated the proportion of interactions that used spatial visualization technologies to the total number of interactions and we took the average values for each modeling week and compared the mean value of multinational virtual project teams and virtual project teams of single nationality; μmultinational>μsingle nationality. According to the t-test result, the difference in use of BSVTs between the two groups is significant with a p value of 0.035. Therefore, multinational virtual project teams tend to use BSVTs more frequently compared to virtual project teams of single nationality.

In Figure 1, we present the average usage of BSVTs and the average direct communications without referring to the visualization technologies. Results indicate a very interesting difference in the collaboration approaches. During the organizational modeling week, both types of teams utilized BSVT at the same level. To finish the first week's tasks, the organizational modeling team projected the 2D models on the shared screen and both teams worked on the 2D model. However, we observed a difference during the second week when teams were utilizing spatial visualization technologies to execute the 4D modeling tasks. While the ratio of multinational virtual project teams referring to spatial visualization technologies is 82.36%, the ratio drops down to 51.13% for virtual project teams of single nationality. In short, about half of virtual project teams of single nationality interactions were direct communications.

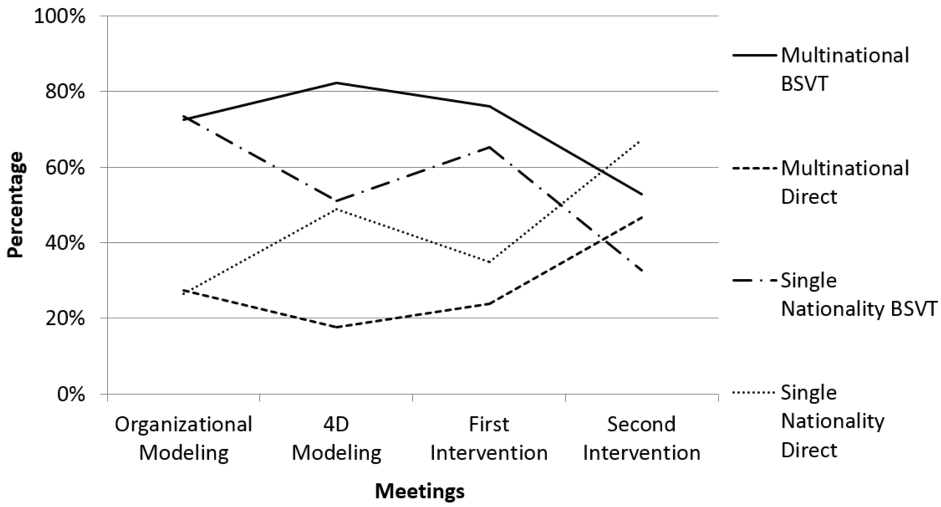

Figure 2: The Average Use of BSVT and Direct Interactions

Moreover, we also checked the significance of the difference in utilizing BSVTs when the tasks were spatially rich. In other words, we applied a t-test only to the 4D modeling and intervention weeks without including the first week which was a 2D, non-spatially rich organizational modeling. According to the t-test result, the difference between multinational virtual project teams and virtual project teams of single nationality is significant with a p value of 0.035. By showing the significant difference of using spatial visualization technologies between multinational virtual project teams and virtual project teams of single nationality, we conclude that it is critically important for multinational virtual project teams to be provided with visualization-supporting tools. Considering that collaborative technologies can reduce the negative effects of diversity early in the life of a diverse team (Staples and Zhao, 2006) and boundary objects establish a shared syntax or language for team members to represent their knowledge (Carlile, 2002), our findings suggest that the multinational virtual project teams were able to overcome the challenges associated with their diversity by referring to the BSVTs more frequently, particularly when the task was spatially rich.

Finally, we examined the relationship between technology use and network cohesion. Social network analytical measures have been applied to examine various phenomena in the architecture, engineering and construction industry for over a decade (see Chinowsky and Taylor (2012)). A key performance metric that can be measured in networks is cohesion. Effective communication is essential in terms of achieving cohesive collaboration, which has been shown to be positively associated with higher levels of performance (Beal et al., 2003). Wech et al. (1998) identified a significant positive correlation between cohesion and effective communication level; Evans and Dion (1991) also support this claim and identify that the frequency and the duration of interactions within cohesive group collaborations contribute to a higher level of performance. Therefore, in order to achieve higher levels of performance in a virtual setting, it is crucial that tools are able to facilitate instantaneous and accurate information transfer. In this sense, using BSVTs within a virtual environment enables better communication since individuals can refer to visualizations instead of or in addition to expressing ideas verbally. Thus, we checked the correlation between the team's network density, an indicator of cohesiveness, and the use of BSVT. We used UCINET to calculate the densities, which are presented in Table 1. The correlation coefficient is 0.74 with a significance value of p = 0.002.

Table 1: The Use of BSVT and the Network Density

Network	Week	Use of BSVT	Network Density
Multinational-1	Organizational	68%	57.67
	4D Modeling	82%	71.80
	First Intervention	75%	47.60
	Second Intervention	79%	44.56
Multinational-2	Organizational	77%	31.43
	First Intervention	77%	80.43
	Second Intervention	27%	26.05
Single Nationality-1	4D Modeling	39%	15.10
	First Intervention	56%	19.80
	Second Intervention	11%	9.90
Single Nationality -2	Organizational	73%	84.63
	4D Modeling	63%	48.17
	First Intervention	75%	61.97
	Second Intervention	55%	48.30

In a virtual setting, the ability to transfer the same rich social, emotional, and non-verbal information present in traditional face-to-face settings is limited. However, BSVT can support effective communication in virtual settings (Koutsabasis et al. 2012). The higher level of BSVT observed in multinational virtual project teams supports this argument as the global teams with linguistic boundaries utilized the technologies more frequently. Since cohesion is positively correlated with higher levels of communication (Wech et al 1998), it is likely we would observe a more cohesive team structure when BSVTs are more frequently utilized. In order to test such a relation, we ran a correlation test and found that, if a project team is encouraged to utilize BSVTs more frequently, then the probability of having cohesive collaboration is 74%. Therefore, the use of BSVTs can support effective communication, which we observe through increasingly cohesive collaboration.

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