

Role of Technology Selection in Supporting Collaboration and Communication in Globally Distributed Virtual Teams

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A Thesis

Submitted in partial fulfillment of the
Requirements for the degree of

Master of Science in Construction Management

University of Washington

2017

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Program Authorized to Offer Degree

Construction Management

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Abstract

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Distributed Virtual Teams

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The rapidly growing trend of using globally distributed virtual teams has taken a step ahead in the industries where it has been practiced for last few decades. The functionality of these virtual teams is highly affected by the mediation of communication and collaboration technologies. It demands that the team members develop leadership skills associated with technology in order to accomplish the team's goals and objectives. With a swift increase in the adoption of new technology, virtual teams are able to function in a more systematic way without losing a significant amount of information. However, it is equally important for teams to investigate and select the most advanced technology for efficient communication and coordination in order to

avoid issues that come up while collaborating in a virtual setup. This thesis studied the existing literature, a research project that involved students participating in a virtual team setup, and the surveys and submittals collected from those student teams. This study emphasized the existing notion of having technological interactions along with transactional and transformational interactions in a globally distributed virtual environment. A detailed analysis of the data collected was performed, which highlighted the role of technology selection in supporting communication and collaboration within these teams. It also portrayed the emergence of new ideas that supported the team members in selecting the most appropriate communication and collaboration tools and helped in eliminating the existing communication and collaboration issues.

Acknowledgement

I would first like to thank my thesis advisor, my mentor **Dr. Carrie Sturts Dossick**, Professor and CERC Executive Director, P.D. Koon Professor of Construction Management, Department of Construction Management at University of Washington. The door to Prof. Dossick's office was always open whenever I ran into a trouble spot or had a question about my thesis. She consistently steered me in the right direction whenever she thought I needed it.

I would also like to thank all the students who were a part of "Innovative Project Management Concepts" class offered in Winter 2016 for this research. Without their passionate participation and input, the data collection and analysis could not have been successfully conducted.

I would also like to acknowledge **Dr. Yong-Woo Kim**, Associate Professor, P.D. Koon Endowed Professor of Construction Management at University of Washington as the second reader of this thesis, and I am gratefully indebted to him for his very valuable comments on this thesis.

I want to express my gratitude to **Dr. Laura Osburn**, Research Scientist, Center for Education and Research in Construction, Department of Construction Management at University of Washington for helping and guiding me all the time. Her contribution to my thesis cannot be expressed in words.

Finally, I must express my very profound gratitude to my parents, to my sister and to my girlfriend for providing me with unfailing support and continuous encouragement throughout my years of study and through the process of researching and writing this thesis. This accomplishment would not have been possible without them. Thank you.

Nishant Bordia

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1 - Introduction

Since the beginning of the 20th century, the world has seen a socio-economic and cultural integration amongst various countries. Globalization has transformed the ways in which transactions between various distributed bodies happen. Companies and businesses around the globe have commenced exploring the opportunities to create workflows between countries in order to expand their work and build relationships for the betterment of their business.

Today, a lot of projects are being executed in a distributed setup. Complex project work in Architecture, Engineering, and Construction (AEC) industry is being outsourced more frequently (Messner, Chen, and Joseph 2007). The reason behind such a change is mostly because of the work quality expectation of the clients and availability of faster delivery methods.

Various organizations with international operations have gradually shifted from the traditional way of communication and collaboration to a more integrated virtual global setup. IT companies like Microsoft, Amazon, Salesforce, etc. have stepped forward with the concept of global projects fashioning workflows between different countries. Not just the IT sector, the construction industry is also getting into this practice of global projects. Companies like Kattera Construction import prefabricated materials from China and provide structural analysis data from teams in India. One of the most reputed contractors in the United States, DPR Construction have teams in Japan and India where 3D and 4D BIM models are prepared and are sent to the team in the United States to work on.

This whole phenomenon of global projects created the concept of globally distributed teams. Distributed teams are teams in which team members are geographically separated from each other. The term distributed team is related to the term virtual team, which is defined as a group of

people, working on an interdependent task, while being geographically separated and of which members, therefore, communicate and coordinate predominantly by means of Information and Communication Technology (ICT) (Powell, Piccoli, and Ives 2004). Chinowsky and Rojas 2002 have defined virtual teams as “A group of people with complementary competencies executing simultaneous collaborative work processes through electronic media without regard to geographic location”. Distinctive features of virtual teams include their preponderant – and at times exclusive – reliance on IT to communicate with each other, their flexible composition, and their ability, if necessary, to traverse traditional organizational boundaries and time constraints (Powell, Piccoli, and Ives 2004). One thing that is clear from these definitions is that there is a very minimal face-to-face interaction between the team members.

In the last few decades, there has been an incremental use of globally distributed virtual teams throughout the world due to developments in information technology, business endurance, and availability of efficient communication resources. Most of the communication takes place electronically using various communication means like emails and video conferencing. In this way, the teams continue to function in a virtual environment as compared to being physically present for the face to face meetings.

Technology has played a very important role in bringing people from different regions together on the same platform. Today, global projects function because of a lot of support from technology, which helps in creating such an environment that aids in the whole process of communication and collaboration. A team functions on the principle of common goals and objectives that need to be preset before starting to collaborate. At the same time, defining tasks and processes for accomplishing the goals and objectives becomes necessary for the teams to

work in an efficient way. Technology accelerates this process of communication and collaboration between the teams.

The functionality of globally distributed teams depends upon a lot of factors which include nationality, culture, efficient communication, trust, teamwork, technology, leadership, management, etc. People from different countries have a different style of working. Cultural differences, many times, have led to difficulties in coordination and communication. The most common issues associated with global teams are language and cultural differences between the team members. Although researchers have shown that the negative effect of cultural differences may be mitigated by an effort to actively understand and accept the differences (Robey, Khoo, and Powers 2000). At the same time, diversity is also important for the overall success of the team. It brings forward the best brains developed in different cultures all together to create something unique. It is a frequent observation that a team member may act as a boundary spanner in order to facilitate communication. When distributed team members from similar backgrounds communicate and collaborate, they already share something in common which totally enhances the process of information exchange. But again, there are issues that might not receive that much weight or attention due to the existence of a boundary spanner. He/she might consider a specific issue to be not as important as the other issues but it might be important for the team as a whole, to know whether that issue needs to be addressed or not.

Building trust amongst the team members is one of the biggest challenges, which a lot of virtual teams face during the initial stage of collaboration. Trusting someone without knowing or meeting them physically becomes very difficult at times. Virtual teams that exhibit high trusting behaviors experience significant social communication as well as predictable communication patterns, substantial feedback, positive leadership, enthusiasm, and the ability to cope with

technical uncertainty (Jarvenpaa and Leidner 1999). Today, technology has a very strong input in bringing all the team members on the same page. Group messaging, conference calling and virtual ice breaking sessions have helped virtual teams to develop trust in their teammates very quickly. Traditional use of technology like emails has always been a plus point for any kind of collaborative work in all industries. Virtual team members nowadays focus on creating a strong bond between the team members. Once that trust is developed, roles and responsibilities are assigned to each team member in context to the task to be accomplished.

Referring to the current trends of the use of distributed virtual teams, it is likely that the application of global teams is going to be more profound and deep in the near future. This whole idea of collaboration and communication in a virtual setup is going to be endorsed by various industries in the coming time. At this point, it is very important for industries practicing virtual collaboration to immerse themselves in the process of understanding how these virtually distributed global teams are managed efficiently and effectively; one of the key factors being leadership.

Leadership in a general way has been talked about in a lot of research work. It is well known that leadership plays a very vital role in the process of accomplishment of tasks and goals within teams. Teams are connected because of the existence of leadership. The output and efficiency of team members increase if they have effective and motivating leaders. On the contrary, leadership has not been discussed much in context to virtual teams. Leadership in distributed teams has become a very hot topic not only because the concept of virtual teams is so much in use but also because there is a high necessity to understand the importance of leadership in globally distributed virtual teams. Many of us have already experienced leadership in some or the other way. Whether it be while taking a class or running a business, leadership have been deeply

associated with all of us. Practicing leadership in collocated setup is completely different from practicing leadership in distributed virtual setup. It becomes a challenge for leaders to manage and delegate processes in a virtual environment mainly because of negligible face to face interaction with the team members.

Because improved communication technologies allow firms to work across the globe, much of the collaboration in the Architecture, Engineering, Construction and Owner-operated (AECO) industry takes place in distributed teams (Taylor and Nayak 2009). Information and communication technologies (ICT) have facilitated the whole process of leadership in virtual teams. (Zigurs 2003) mentioned that virtual groups provide us a unique opportunity to redefine leadership. This new work environment that is completely virtual and supported by the technology has made it possible for leaders to manage and lead projects without being physically present. Virtual training, feedback, and leadership mostly occur in a digital arrangement and leaders are tending towards adapting to these parameters in order to manage the designated work. It can be inferred that technological development has given rise to a new approach of leading projects in a distributed setup and hence leadership is encouraged to be practiced from a technological perspective for virtually distributed teams.

A lot of researchers question the existence of a different kind of leadership for virtual teams. It is argued that traditional leadership and leadership in virtual teams is not different, it is the medium (for example, ICT) for implementing the goals and objectives associated with the roles and tasks that is different. But, it is also a fact that leaders have a lot of reliance on the information and communication technologies and while managing the project, leaders face a lot of challenges and difficulties. Virtual teams present special challenges, particularly in the expression of the context-rich and personal influence that is such an important part of leadership (Bell and

Kozlowski 2002). This indicates that there is a need for a particular skill set for managing virtual teams and that skill set needs to be different from or in addition to the existing traditional leadership skill set. Virtual teams require proper training so that they can manage tasks by themselves, which will ultimately lead to the emergence of self-leadership skills.

Scholars who study leadership in globally distributed virtual teams have identified three styles of interaction: transactional, transformation and technological (Iorio and Taylor 2015). Transactional leadership mostly revolves around an exchange happening between the leader and the followers. A transactional leader offers gifts and rewards to the team members/followers once they get done with their tasks and reach their goals. These goals and objectives are formulated by the transactional leader and are then distributed amongst the team members. In case the goals are not achieved or team members fail to reach their goals, the leader imposes penalty or punishment on the team members. Transformational leadership is more about developing self-leadership skills within the team itself by motivation, commitment, and respect. Transformational leadership is based on four principal factors: idealized influence (or “charisma”), inspirational motivation, intellectual stimulation, and individualized consideration (Bass and Avolio 1993). Transformational leaders inspire the team members, enhance their interest in the tasks, guide them in the right way to produce new ideas, give them opportunities to solve problems and issues while maintaining the decorum and respect for all the team members.

Human interaction with technology gave rise to the requirement of technological leadership within virtual teams. A technological leader is one who finds solutions to technical issues while communicating and collaborating in a virtual world and becomes a resource for the team for managing technical uncertainties. A technological leader makes sure that the communication between the virtual teams is not hindered by any kind of issues associated with the technology in

use. He/she also finds alternatives to poor/obsolete communication tools and helps in bringing the team on a more convenient technological platform to collaborate and coordinate effectively. It is very important to have a technological leader on the team because, in virtual teams, there is negligible face-to-face or physical interaction between team members. When teams are also distributed in time, leaders will have more difficulty with performance management, as they may encounter a delay of information of events, which is also provided without information about the immediate context in which something occurred. Keeping in mind the existing issues like time constraints, time zone difference and cultural difference experienced by the virtual team members, there is a necessity of having a technological leader on the team who can make the process of collaboration and communication easier by providing the correct communication tools and performing hands-on problem solving for issues that occur while performing the tasks. Sometimes, the available technology needs to be organized to meet the demands of the team members. A technological leader should also be able to play around with the existing technology in case the latest technological environment is difficult to be made available to the team.

1.1 - Research Question

Looking at the goal and scope of this thesis, the research question was answered by emphasizing the importance of technology selection in the process of collaboration and communication in globally distributed virtual student teams and how it increased the communication efficiency between team members. This thesis studied the preliminary data, surveys, and reflections in the submittals by the students to eventually reinforce the idea and requirement of selecting advanced technology in a distributed setup, which will act as a data specification. This study also covered the student interaction with technology and talked about how a few team members came up with the ideas of switching to a newer technology to provide the team a better platform for

communication and information exchange. Therefore, the following research question will define the crux of this thesis, **“How does technology selection support collaboration and communication in globally distributed virtual teams?”**.

2 - Literature Review

This chapter provides an overview of the existing theory on virtual teams. It includes vital information about virtual teams, their functionality and operation. It also includes the current studies on leadership in virtually distributed teams. Technological leadership has also been covered in this chapter spanning on its prevailing involvement in the world of virtual collaboration.

2.1 - Defining Virtual Teams

Global competition, reengineered product life cycles, mass customization, and the increased need to respond quickly to customers' needs are some of the pronounced trends currently driving organizational change (Grenier and Metes 1995). Due to this organizational change happening around the globe, companies are looking forward to technology as a medium to accelerate the communication and collaboration globally in order to stay strong in the competition. One of the reasons why these organizations are successful is an efficient implementation of the usage of virtual teams.

Before understanding what exactly virtual teams are, it is important to define the term 'team'. As described in many research papers and publications, a team is a collection of individuals that works on organizational tasks interdependently, shares responsibility for team performance, and is viewed as a distinct social entity embedded in a larger organizational system (Cohen and Bailey 1997). A team is a general term that doesn't portray its global nature. Virtual teams with the input from technology supplements the phenomenon of global collaboration. Townsend, DeMarie, and Hendrickson 1998 defined virtual teams as "groups of geographically and/or organizationally dispersed coworkers that are assembled using a combination of

telecommunications and information technologies to accomplish an organizational task.” Another definition by Kristof et al. (1995) states that a global virtual team is a temporary, culturally diverse, geographically dispersed, electronically communicating work group (Figure1).

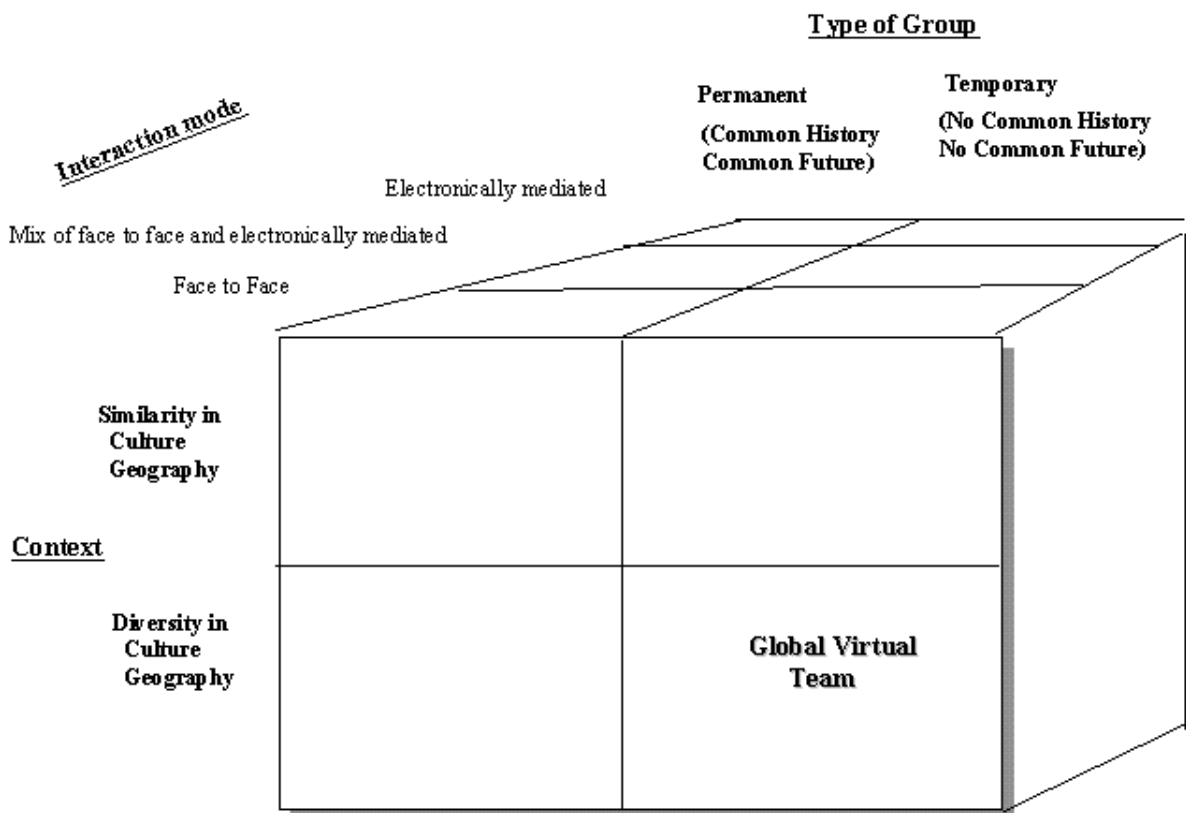


Figure 1: Definition of global virtual team

Most of the globally distributed virtual teams are formed for a short span of time and the same team members may not get a chance to work together again in the future. The typical virtual project team is characterized by temporary lifespan and membership (Bell and Kozlowski 2002), spatial dispersion (Zigurs 2003), and the use of predominantly computer-mediated communication (Driskell, Radtke, and Salas 2003). One of the reasons why the study of virtual teams has gained importance is because the team members belong to different countries and cultures, and the only way to keep them connected is by the means of information and

communication technologies. Virtual teaming is a new way of managing and organizing work that allows people to work together even though they are geographically separated (Gazor 2012). Virtual teams allow organizations to access the most qualified individuals for a particular job regardless of their location, enable organizations to respond faster to increased competition, and provide greater flexibility to individuals working from home or on the road (Hunsaker and Hunsaker 2008).

Traditional teams as compared to virtual teams receive the benefit of face-to-face interaction. Virtual teaming, where people work together apart, has been found to be very different to traditional teaming, where people work together (Virtual Teaming Association 2003). There is always a physical presence of members that aids to the process of communication in traditional teams. The gestures, physical reactions (movement of limbs), and physical attendance of team members add richness to the conversation. Achieving this richness in virtual teams becomes a big challenge for the team members because they miss out on that 'physical presence' of the team members. Sometimes, it becomes really challenging to figure out issues between team members as they keep on building up slowly. Virtual teamwork is more complex than working face-to-face (Heimer and Vince 1998).

While there are many pros of virtual teams, there exists a bunch of researches that highlight the cons too. Discontinuities like low individual commitment, role overload, role ambiguity, absenteeism, and social loafing may be exaggerated in a virtual context (O'Hara-Devereaux and Johansen 1994). Moreover, customers might perceive a lack of permanency, reliability, and consistency in virtual forms (Mowshowitz 1997). Recommending only limited use of the virtual setting in global teams, some inculcate initial lengthy face-to-face gatherings with repeated same time and same place encounters scattered throughout the project (De Meyer 1991).

On the contrary, virtual teams have improved the process of collaboration and communication with the help of information and communication technology (ICT). Credits must be given to ICT for bringing together the team members in a virtual setup where they can now be effectively rebuilt. Only because of the recent improvements in the computer technology, we are able to see highly efficient virtual teams functioning throughout the world. Although all of the systems are somewhat interdependent, it is helpful to consider them as belonging to one of three broad categories of technology: desktop videoconferencing systems (DVCS); collaborative software systems; and Internet/Intranet systems (Townsend, DeMarie, and Hendrickson 1998). These three technologies provide an infrastructure across which the virtual team will interact and provide technological empowerment to the virtual teams' operation (Osterlund 1997).

2.2 - Functionality of Virtual Teams

Virtual teams function because of a lot of parameters that govern the performance of the team as a whole. It is important to understand these parameters in order to create a successful and efficient virtual team, and to create better workflows between team members. A few parameters that will be covered in this section are: Trust, relationship building, cultural differences, distance and time difference, training, information and communication technology, and leadership.

Saunders (2000) presented a life cycle model that includes the above mentioned parameters organized in different categories of variables (Figure 2). These parameters affect the functionality of virtual teams in a great way.

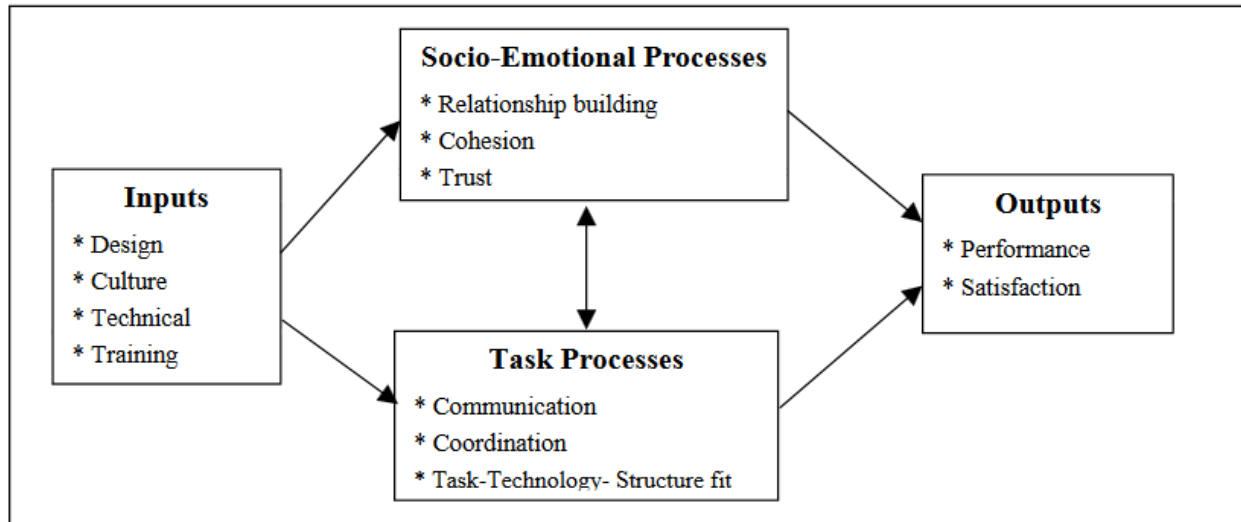


Figure 2: Life-cycle model for virtual teams

2.2.1 - Trust

Trust is based on the belief that team members are dependable meeting the team expectations by delivering what they promise, which is seen as highly important in virtual teams as trust will be established by repeatedly setting expectations and delivering results that meet or exceed those expectations (Cascio and Shurygailo 2003). In conventional teams, trust develops quickly because of face-to-face interaction. One of the key concerns in virtual teams is to develop trust. As mentioned earlier, technology alone doesn't support the functioning of virtual teams. It is important for trust to work in association with other parameters for a virtual team to function. Handy (1995) mentioned that if we are to enjoy the efficiencies and other benefits of the virtual organization, we will have to rediscover how to run organizations based more on trust than on control. Virtuality requires trust to make it work. Technology on its own is not enough.

It becomes a big challenge for the team members to develop trust because of the fact that team members do not know or haven't met each other personally before commencing the project. Additionally, the span for which these virtual teams exist is so small that it becomes necessary to develop trust as quickly as possible so that sufficient time is left for actually performing the tasks

involved in the project. Previous studies on trust building have shown that virtual teams develop trust rather quickly by assuming that the trust between team members already exists while communicating solutions and performing specific roles and responsibilities. Developing trust helps in building a structure that facilitates control and coordination between team members.

Since it is clear that trust plays a very important role in the functioning of virtual teams, it is necessary for team leaders to keep the team together and maintain the balance between team integrity and work output. Leaders that diminish uncertainty, enhance coherence, set expectations that commitments will be fulfilled, promote joint efforts, create positive climate and dynamics to meet joint challenges, establish standard procedures, enable creation of shared understanding for effective decision making, enhance knowledge management, increase team motivation, and above all, communicate effectively by applying information and communication technology matching the right tasks with right electronic communication channel (Lilian 2014). With these efforts coming out of a leader, the team members will definitely develop trust among themselves, thus benefiting the whole process of virtual collaboration and coordination.

2.2.2 - Relationship Building

Socialization is the building block of developing any new relationship. Similar concept applies for virtual teams also. As it is known, virtual team interaction is mostly electronic. Team members do not get a chance to meet each other physically. They tend to develop relationships via video conference calls and audio communication that, as compared to conventional teams, are difficult to nurture. This happens because virtual team members are more task-oriented rather than being socially oriented initially. However, it is observed that overtime, virtual teams tend to lessen their task orientation (Chidambaram and Bostrom 1993) and begin to socialize more.

It is therefore, important for the team members to interact electronically as early as possible before starting to work together. Reliance on phones and emails all the time hinders the free flow of information. It is recommended to use tools like video or instant chatting to resolve problems and build strong ties with the team members. As it is clear that, face-to-face interaction is nearly impossible in virtual teams, leaders need to understand the importance of relationship building in order to achieve the project targets and goals. Effective leaders have been found to be able to stimulate relationship building by facilitating socialization among virtual team members by scheduling regular chat sessions with all team members present and using humor to lighten moods (Kayworth and Leidner 2002).

Computer technology has revolutionized the way today virtual teams collaborate. It is because of technology that team members are able to communicate efficiently without incurring information loss. Relationship building has become way much easier after these communication tools have started to pop up in the industry. Team members feel more connected to each other exchanging information electronically.

It was also observed that cultural differences, many times, affect the process of relationship building. Every team has a different style of functioning. Some teams prefer to socialize at the very beginning of the project and some prefer to socialize after completion of the project. It is the role of a leader to ensure that the diversity on the team is understood, appreciated and leveraged (Fudin 2013). Team members should show respect to each other regardless of their cultural backgrounds. When team members represent a variety of national or cultural groups, there will also be the need to teach team members how each of their respective cultures may differ and how they can overcome these differences and use them to the team's advantage (Townsend, DeMarie, and Hendrickson 1998).

2.2.3 - Cultural Backgrounds and Differences

Cultural behaviors interfere with the communication happening between team members of different background. Individuals from different cultures vary in terms of their communication and group behaviors including the motivation to seek and disclose individuating information and in the need to engage in self-categorization (Gudykunst 1997). Today, virtual teams are formed by team members coming from different countries and different cultural backgrounds. Companies tend to create a diverse group as they are operating their businesses internationally and hence lose out on effective communication and strong workflow management due to existence of cultural and linguistic barriers in the group. Brunelle (2012) mentioned that diversity affects members' behavior and working practices and may, hence, complicate communication and identification processes and the execution of work.

Having problems in communication due to cultural differences doesn't mean that those problems cannot be mitigated. A lot of team members have exposure to various types of cultures that exist in the world. They tend to communicate in a more efficient way as compared to those who do not have a prior knowledge of the team members' cultural backgrounds. Not just better communication, they tend to develop better trust amongst themselves. This is true because those team members indirectly have a very unique way to start a conversation. Wiseman, Hammer, and Nishida (1989) also agreed to the fact that previous cultural exposure is an important factor, which influences communication behavior.

A very influential factor, which has not been highlighted much in research work is the phenomenon of boundary spanning. One of the challenges for the leaders of virtual teams is not just to alleviate the cultural differences but also look out for the team members show span across countries culturally. Boundary spanners can be both beneficial and unnecessary for the virtual

teams. For instance, a boundary spanner can communicate with the team members of similar cultural background in similar language and collect information for the rest of the team members. He/she can act as a virtual information controller for the whole team. On the other hand, a lot of information may be lost due to ignorance of the boundary spanner on an issue that might be very crucial for the overall progress of the team.

Leaders should make sure that team members possess a genuine respect for all cultures involved in the coordination process. At the same time, it is important to hold respect and commitment to the work, which has been assigned to respective team members. Leaders may use technology as a medium to build the cultural relationship within the team. Leaders must develop traits, which help them in handling team members from different cultural backgrounds and avoiding conflicts between team members.

2.2.4 - Distance and Time Difference

One of the major concerns in virtual world collaboration is the physical distance between the virtual team members. The whole concept of virtual team functions on the placement of the team members that can be anywhere throughout the world. Whereas the members of traditional teams work in close proximity to one another, the members of virtual teams are separated, often by many miles or even continents (Townsend, De Marie, and Hendrickson 1996). Distance in working relationships can be physical when produced by geography, time zone or organizational size; operational when related to team size as well as to opportunities for communication and face-to-face meetings or cultural, based on different values, prior familiarity, and status (Shuffler et al. 2010).

It is well known that virtual teams communicate by using various communication technologies that include emails, phone calls, instant messaging, webcams, internet and video conferencing. Although, the actual distance between the team members cannot be decreased, but technology definitely brings them on the same platform and allows them to interact and communicate virtually. This communication is not as rich as what conventional collocated teams experience but it is sufficient enough for the team members to coordinate and communicate efficiently.

Virtual teams allow organizations to become more flexible, adaptive, and responsive by enabling them to cross boundaries of space (Bell and Kozlowski 2002). It is important to note that virtual teams benefit the organizations by providing faster communication and quick adaptability to changes. Knowledge of the team members can be quickly put to application regardless of the location. In this way, the organizations get the most unique and technically specialized expertise of the team members.

Time zone difference is another big challenge for the virtual teams. While working in a completely virtual setup, team members frequently fail to find a common time to meet, communicate and discuss issues online. Time-related challenges rise partly from the geographical distances meaning that the team members are typically working in different time zones without overlapping work hours and, consequently, the different time zones hamper simultaneous work (Cummings 2011).

Leaders in virtual teams need to make sure that distance and time don't serve as a botheration for the team members. They should make sure that the communication technologies are efficient enough to serve the purpose of collaborative work. Leaders should also focus on creating stringent schedules and fixed deadlines in order to achieve the set goals. Team members should stick to those deadlines and work in conjunction with the leader supporting him/her in all ways.

Team success and value can be achieved easily if leaders focus on eliminating issues, which arise by distance and time difference in virtual teams.

2.2.5 - Training

Training is important for the team members of any team to perform in a more efficient way. Conventional teams have shown that training the team members results in the increase of the team performance as a whole. On the other hand, virtual teams characterized by diverse technology skills may experience conflict when members are unable to resolve differences and compromise on the use of a specific skill during task completion (e.g. deciding to work through emails instead of having a common texting/chatting platform to bring all team members on the same page) (Sarker and Sahay 2002). It is commonly seen that training for virtual teams mostly revolves around making the teams author technical software skills and not the communication tools and dynamics.

While it is important to train the team members for technical software skills; at the same time, it is important to train them in the direction of developing effective communication skills in order to run the process of collaboration and coordination successfully. It is important for organizations to accelerate the acceptance and utilization of Computer Mediated Communication Systems (CMCS) technologies by training team members in relationship building (Warkentin and Beranek 1999).

Recent research shows that teams that received virtual team communication (VTC) training felt that their team exhibited trust, that team members were committed to the goals and objectives of the team, and that team members were open and frank in expressing their ideas and feelings (Warkentin and Beranek 1999). Leaders should focus on providing VTC training to team

members in order to progress cohesiveness within the team members. Keeping in mind that technology is improving day by day, leaders should motivate team members to derive new ways in which they can communicate and coordinate more efficiently. This training would help the team members to drift towards teamwork satisfaction and develop trust within themselves.

2.2.6 - Information and Communication Technologies

One of the very prominent reasons why virtual teams are different from conventional teams is due to technological mediation. Information and communication technologies (ICT) have played a very important role in making the communication process easier and more efficient. Romero and Molina (2009) mentioned that ICTs are based on collaboration and contribute to competitive advantage, innovation, and economic growth as they enable global access to individual capabilities, best skills, and core competencies. They bring the best talent and expertise available in the world on the same page in order to create workflows between distributed team members.

It has been observed that success of a team highly depends on effective communication and high levels of knowledge sharing. A lot of research papers discuss the importance of communication focusing on the need to create a team of excellent communicators, on the selection of the right technology for most effective communication (Alexander 2000). Technology has been in use in virtual teams from a very long time. emails, text messages, voice mails have been (in the past) and are being used in all kinds of teams, whether it be virtual or conventional. But the evolution in computer mediated communication (CMC) has led to the emergence of what Sproull and Kiesler (1991) call the 'networked organization'. Many organizations are using ICTs for problem solving, improved communication means, team operation and coordination.

It is evident that face-to-face interaction on virtual teams is next to nothing or negligible as compared to what we see in conventional teams. In such conditions, communication technologies are vital for collaboration (Hollingshead 2004). The logic behind companies/organizations extensively using and investing in the concept of virtual teams is due to a great development in the computer and communication technologies in the past few decades. Few technical obstacles remain for communication and collaboration across geographic boundaries, as these processes are supported by high tech collaboration solutions (Verburg, Andriessen, and de Rooij 2005). There has been an increasing reliance on information and knowledge diffusion through electronic means rather than through traditional face-to-face communication (Olson-Buchanan et al. 2007). In the 21st century, teams are not just using emails and text messaging, there are actively using other communication tools that help in communicating and coordinating between team members more efficiently. Dennis and Valacich 1999 provided a list of widely used communication and coordination tools that are available to support work in distributed teams (Table 1).

Communication tools	Coordination tools
Telephone (one-on-one/voice over IP)	Shared directory in internet
Telephone conferencing or voice over IP (VOIP)	Shared databases
Videoconferencing rooms	Project management groupware
Online chat	Workflow management software
Desktop videoconferencing	Learning environment
Text messages (SMS)	Team website (team space)
Multimedia messages (MMS)	Team workspace
Special discussion lists	Shared team calendar
(Desktop) web conferencing (webcam and voice)	Group Decision Support Systems (GDSS)
(Desktop) data conferencing (Netmeeting, shared excel, or Web-x)	Electronic Whiteboards or Smart boards
Instant messaging	Wiki
E-mail	

Table 1: Communication and coordination tools for distributed teams

These tools are extensively being used by virtual teams. A majority of applications and tools are specifically developed for better communication. At the same time, a lot of tools have been created to avail a virtual environment to the team members where they can see (virtually) who all are participating in the collaboration as well as share information by texting, talking and screen sharing. Although email is probably the most common, other more complex and interactive communication technologies, such as videoconferencing, groupware, and project management software, are growing in popularity (Geber 1995). With the enormous increase in people and organizations who are connected to the internet, and the increase in bandwidth that has been realized over the last decade, very advanced tools for distant collaboration such as high quality (desktop) videoconferencing, electronic whiteboards, smartboards, and groupware are now available (Andriessen 2012). They allow individuals to communicate and share information and data regardless of their location in time and space, and are the primary means by which the members of virtual teams interact (Bell and Kozlowski 2002). This information exchange takes place in real-time and hence, the information is gathered and understood at the same time. Virtual teams that make greater use of technology-mediated communication are more likely than those with lesser use to engage in more task, relational, and process knowledge exchange, thereby resulting in less task conflict, relational conflict, and process conflict (Wakefield, Leidner, and Garrison 2008).

Researchers have found that collaborative technologies (e.g. the Internet, the World Wide Web, Web Services, global digital networks, integrated development environment, virtual prototyping) combined with groupware, can facilitate knowledge management and information dispersion, which enables shared understanding within global project teams (Raisinghani et al. 2010). The use of Building Information Modeling (BIM) is one such example that is used meticulously in

the Architecture, Engineering and Construction (AEC) industry. It allows to build a digital representation of all the information (from start to end) available about the project.

Research on computer-mediated groups finds that groups specifically choose the technologies that best meet members' needs (Hinds and Kiesler 1995) and use these technologies to engage social processes (Hertel, Konradt, and Orlikowski 2004). The choice of technology depends on individual preferences, individual experience with the technology and its ease of use, the need for documentation, and the urgency of the task (Robey, Khoo, and Powers 2000). Although the specific communication technologies a virtual team employs depends to some extent on an organization's resources, the choice should be dictated by the nature of the task the team is performing (Bell and Kozlowski 2002). Team members of a virtual team, before initiating any project, meet to discuss about the logistics associated with the project. After finalizing the logistics, adaptability to the technology in use is also very important for the team members. Effective virtual teams appear to be able to adapt the technology and match it to the communication requirements of the task at hand (Maznevski and Chudoba 2000).

While most virtual team members have a positive experience working across space and time, the biggest area of complaint involved communication problems (Grenier and Metes 1995) for example lack of project visibility, difficulty in contact, and technology constraints (Hunsaker and Hunsaker 2008). Most information technology projects tend to face problems and risks, and great deal of such projects fail to reach all their objectives (Raisinghani et al. 2010). It is known that conventional teams work in an environment where collaboration and information exchange happen efficiently due to the physical presence of the team members. On the contrary, the virtual environment presents considerable challenges to effective communication including time delays in sending feedback, lack of a common frame of reference for all members, differences in

salience and interpretation of written text, and assurance of participation from remote team members (Cramton 2001; Mark 2001).

One of the earliest theories explaining the relational effects of technology mediation is social presence theory, which argues that interpersonal and group processes are negatively affected when people interact over media that reduce their feeling of “being there” with their communication partners (Short, Williams, and Christie 1976). Relational information exchange gets lost in virtual team collaboration due to lack of face-to-face interaction as compared to conventional collocated teams. Computer-mediated communication reduces nonverbal cues about interpersonal affections such as tone, warmth, and attentiveness, which contribute to message clarity and communication richness, and collaborators who use computer-mediated communication often use more direct styles of communication with fewer social cues than those in face-to-face conditions (Tidwell and Walther 2002). Because of delays in transmission and the lack of social and nonverbal cues, communication technologies can interfere with open communication, knowledge sharing, and the ability of teams to identify and resolve misunderstandings (Gibson and Cohen 2003).

Leaders must understand that computer technology is a great tool for team communication but at the same time has a lot of limitations. They should focus on understanding and developing the best way possible for the team members to communicate and coordinate. Communication through technology, at times, can be overwhelming for the team members and it needs to be controlled by the leader of the team. Research shows that leader-follower interactions can be improved with the use of technology (Walvoord et al. 2008). The leaders of virtual teams must work cooperatively with their team members and establish strict guidelines concerning not only ‘what’ and ‘when’ to communicate but also ‘how’ to communicate (Ojala 2004).

Virtual team leaders should focus on creating self-managing teams by distributing the responsibilities within the team. In this way, even if there are issues in computer mediated communication, the team will still function. Because technology is unpredictable, it is important for a leader to find an alternative if technology fails to fulfill the task of team members' communication. Leaders should make sure that all the information and knowledge get communicated to all the team members, or in other words, ensure zero loss of information and knowledge. They should try to reduce the conflicts between the team members regarding the technology being used for information exchange by replacing the obsolete communication tools.

2.3 - Leadership in Virtual Teams

Leadership has played a very important role in improving the performance and efficiency of teams. A great deal of research has revealed that leaders make a critical difference in team performance. They play important roles in modeling teamwork and in setting ground rules for team members to engage successfully in teamwork processes (Cascio and Shurygailo 2003). Research has also shown that leaders in virtual teams have same or similar roles as seen in conventional teams where interaction is face-to-face. Leaders make a critical difference in team performance, and it seems that such findings are also applicable to virtual teams (Cascio and Shurygailo 2003).

2.3.1 - E-Leadership

Contributors to the research of leadership have derived various models, which help in understanding the conceptual foundation of leadership in a conventional setup. Unfortunately, virtual team leadership has not been discussed a lot and there is a scarcity of leadership research.

However, a few researchers have talked about 'E-leadership' (Avolio and Kahai 2003) in this context.

Avolio, Kahai, and Dodge (2001) defined E-leadership as "a social influence process mediated by advanced information technology (AIT) to produce a change in attitudes, feelings, thinking, behavior, and/or performance with individuals, groups, and/or organizations". They further mentioned that it is important to consider how AIT interacts with leadership to influence both the structure and effects of leadership and how leadership, in turn, might influence AIT's adoption and effects on organizations. Technology is constantly associated with E-leadership, which means that failure in technological systems will result in failure in E-leadership. As current business environment and the challenges E-leaders face differ from those in traditional leadership, E-leadership may be seen as a new and expanding context in leaders' work reflecting the new E-era to leadership (Savolainen 2013).

Performance management and team development are two basic function of E-leaders (Hunsaker and Hunsaker 2008). In order to achieve a good performance in virtual teams, E-leaders should set the goals and visions, stipulate the direction of all tasks for all members and establish routines and habitual meetings and standard operating procedures clearly. Additionally, in order to develop virtual teams, E-leaders have to create opportunities for building trust among all team members and encourage incentives through providing the recognition for success. E-leaders should provide interim performance-management checkpoints, especially if there are any outstanding issues to be resolved (Cascio and Shurygailo 2003).

The challenges of E-leadership have been previously explained and discussed in the literature review. It is the duty of the E-leader to take the responsibilities of the outcomes of these

challenges and derive a solution for the team members. E-leaders should monitor the work of the team members regularly and take swift and correct action to tackle the issues.

2.3.2 - Transactional Leadership

One of the research models, which is really popular in the study of virtual team leadership is Full Range Leadership Model proposed by Bass and Avolio (1990). It included two types of leadership concepts: transactional and transformational leadership.

Tyssen, Wald, and Spieth (2014) explained that transactional leadership focuses on the task-related exchange of actions and rewards between follower and leader. Bass (1985) elaborated the three behavioral categories of transactional leadership. The first, *contingent reward*, describes leaders providing clear goals and clarity about rewards when these goals are met. The second category, *management by exception active*, describes leader behaviors aimed at actively ensuring that the standards are met. Finally, the third aspect is called *management by exception passive*. This meant that the leaders are more particular about the standards to be achieved first before they start to interfere in the process. In transactional leadership, followers are encouraged to fulfill self-interests.

Graen and Uhl-Bien (1995) arrived to a conclusion that transactional leadership is associated with low quality exchanges between followers and leader. This notion was later revised by Howell and Hall-Merenda (1999) who stated that leaders who practice contingent reward, which represents a positive, constructive transaction between leaders and followers in which followers are rewarded or recognized for achieving agreed on objectives, may also engage in higher quality dyadic relationships. On the other hand, leaders who engage in active and passive management-by-exception with followers, a corrective transaction that emphasizes negative

feedback and reinforcement rather than the positive reinforcement used with contingent reward leadership, may have lower quality of relationships with their followers.

2.3.3 - Transformational Leadership

Transformational leadership deals with managing interpersonal relationships between team members and the leader. Bass (1985) mentioned about the four behavioral categories of transformational leadership. Purvanova and Bono (2009) & Bass and Avolio (1993) stated that transformational leadership is comprised of idealized influence (also referred to as charisma), inspirational motivation, intellectual stimulation, and individualized consideration behaviors. Leaders are charismatic when they inspire devotion and loyalty, display a strong commitment to ideals, and emphasize the importance of a collective mission. Leaders are inspirational when they appeal to employees' feelings and emotions, transmit an enthusiastic vision of the future, and express confidence about successful completion of goals. Leaders are intellectually stimulating when they question assumptions, challenge their employees intellectually, and encourage re-thinking of ideas. Leaders are individually considerate when they recognize the unique needs and abilities of their employees, treat employees as individuals, and coach and develop their employees (Purvanova and Bono 2009).

Characteristics	Sources
Clear sense of purpose, expressed simply (e.g. metaphors, anecdotes)	Lussier & Achua (2004)
Value driven (e.g. have core values and congruent behavior)	Epitropaki (undated)
Strong role model	Hall, Johnson, Wysocki & Kepner (2002)
High expectations	Hall, Johnson, Wysocki & Kepner (2002)
Persistent	Lussier & Achua (2004)
Self-knowing	Cox (2001)
Perpetual desire for learning	Cox (2001)
Love work	Cox (2001)
Life-long learners	Bass (1990a)
Identify themselves as change agents	Bass (1990a)
Enthusiastic	Bass (1990a)
Able to attract and inspire others	Avolio and Bass, (2002)
Strategic	Avolio and Bass, (2002)
Effective communicator	Russell and Stone (2002)
Emotionally mature	Russell and Stone (2002)
Courageous	Epitropaki (undated)
Risk-taking	Russell and Stone (2002)
Visionary	Bass (1990a)
Unwilling to believe in failure	Epitropaki (undated)
Sense of public need	University of Regina (undated)
Considerate of the personal needs of employees	University of Regina (undated)
Listens to all viewpoints to develop spirit of cooperation	Tichy & Devanna (1986)
Mentoring	Russell and Stone (2002)
Able to deal with complexity, uncertainty and ambiguity	Tichy & Devanna (1986)

Table 2: Characteristics of transformational leader

Table 2 enlists all the characteristics of transformational leaders. Transformational leaders are skilled at increasing and broadening follower interests, gaining commitment to the goals and mission of the group/organization, and motivating people to go beyond their self-interests for the good of the group (Den Hartog and Koopman 2001).

2.3.4 - Comparison Between Transactional and Transformational Leadership

Most of the experimental studies on leadership in virtually distributed teams have compared transactional leadership with transformational leadership. Some research has evaluated that transformational leadership is more effective than transactional leadership (Bass 1997). Effective leaders who adopt a transformational style of leadership may engage in interactions that support rapport building (Kayworth and Leidner 2002; Zaccaro and Bader 2003) while those who adopt a transactional style engage in interactions that may assign tasks and roles to individuals (Cordery et al. 2009; Huang, Kahai, and Jestice 2010). Transformational leaders have also been identified to have a strong, positive influence on subordinates' commitment, which is fundamental to the successful outcome of project (Christenson and Walker 2004) as compared to transactional leaders.

Some researchers also commented that transformational leadership compliments transactional leadership and that leaders enhance their transactional leadership skills by adding transformational leadership traits (Howell and Avolio 1993).

On the contrary, some findings suggested that in achieving high levels of group effectiveness, transactional leadership outstands transformational leadership (Kahai, Sosik, and Avolio 2003). However, it is clear that these leadership styles often get equalized or transformational leadership becomes more effective in situations involving anonymity, which is mostly observed in virtual teams communicating through advanced computer technology or when the communication medium becomes anonymous (Sosik et al. 1998).

2.3.5 - Concept of Technological Leadership

As discussed earlier, information and communication technologies (ICT) play a very significant role in the process of information exchange and collaboration in virtually distributed global teams. It is also evident that a lot of research has been done on transactional and transformational leadership in virtual teams. However, leadership associated with technology hasn't been explored to its maximum yet.

Iorio and Taylor (2015) argued that in addition to engagement in transactional and transformational interactions, effective leaders must also engage in technological interactions. Further, Iorio, Taylor, and Dossick (2012) suggested that virtual team leaders should modify their ways of interaction in order to carry out knowledge and information transfer across technological boundaries more efficiently. It is important for virtual team leaders to adjust and engage themselves according to the constraints they come across while being mediated by technology for communication amongst the team members.

Communication and coordination between virtual team members pose a big challenge in front of the virtual team leaders. Advanced communication and collaboration technologies help them in overcoming those challenges. It is true that if communication technology fails to operate correctly, then it reduces the team effectiveness to function together and also reduces the productivity.

This thesis focused on emphasizing the importance of technology selection in the process of collaboration between globally distributed virtual student teams and how it increased the communication efficiency of the team members. It addressed all the communication errors and constraints faced by the teams communicating and collaborating globally. It depicted how these

constraints give rise to leaders from within the team to emerge as technologists who would amend these constraints in order to maintain the flow of work and information exchange. It studied the preliminary data, surveys, and reflections in the submittals by the students to eventually reinforce the idea and requirement of selecting advanced technology in a distributed setup, which will act as a data specification. This thesis also shared circumstances and situations that team members overcame as a whole to mitigate communication and collaboration issues. It presented how technology selection supported the process of communication and collaboration in globally distributed virtual teams.

3 - Methodology

To validate and answer the research question, data from the course named ‘Innovative Project Management Concepts’ or CM515, which is offered every year in the Winter quarter to Graduate level students, was collected. For the thesis, the data was collected and analyzed only from the student teams participating in this class of Winter 2016 at the University of Washington. The data collected, thus, was reviewed and analyzed to present results in the data analysis section of the thesis. Qualitative and quantitative analyses was conducted to produce results that support the idea behind this thesis.

3.1 - Virtual Lab: Global Teams

For the last six years, research has been going on around the concept of virtual teams at the University of Washington. Dr. Dossick being the Principal Investigator for this research, started the concept of Virtual Lab (VLab) and decided to conduct this research involving student participation every year. It was completely on student’s discretion to participate in this research. Upon making the decision to participate in the research, students signed on the consent form approving their complete participation in the research.

3.2 - About the Research Study

This research project studies collaboration in global virtual design teams working on construction planning projects in the classroom. This is an exploratory project that aims to investigate communication and social issues in 2D virtual team spaces (Sococo) and their impact on construction planning outcomes. Students were asked to participate in this project because they were construction management or engineering students at the University of Washington and

taking CM515 in the winter quarter 2016. To participate in the experiment, they must be between 18 and 88 years of age.

3.3 - Proceedings for the Study

During this class, UW students worked together with students from Indian Institute of Technology Madras (IIT) in virtual teams to complete two projects. The first project consisted of completing a Construction Schedule and integration of IIT's Revit model and baseline schedule to develop a 4D model in Navisworks, and the second project consisted of completing a BIM Execution and then a 4D model in Navisworks in collaboration with IIT. Students worked in a 2D virtual working environment called Sococo to collaborate with their teams.

For the research project and thesis, we collected the student project work (final presentations and classroom deliverables detailed in the project description) as data. We also distributed the feedback survey (See Appendix A) at the end of each of the two class projects to better understand how often were the team meetings conducted, what they enjoyed during collaboration, and what difficulties they encountered during collaboration. These surveys were later collected as a part of the research data set with a condition that these assignments and survey data would not be shared beyond the University of Washington research team.

Just as with any other course taught at the University of Washington, we addressed withdrawal on a case by case basis. If students were taking the class as an elective, they could drop the class at any time. If they wanted to continue with the class, but wanted to drop out of the research study, we immediately deleted all data related to their team and their team was removed from the study (as it was impossible to remove an individual from the analysis). If they were unable to withdraw because they had to take the class to graduate from the program, we removed their

team from the study, immediately destroying any data associated with them, while they completed the class activities. The students were made clear about the risks, stress and discomfort they might experience while working with teams overseas and tight schedule. It was made sure that withdrawal from the study, but remaining in the class, would not affect the grade of the students in the class, their reputation in the university or the industry.

3.4 - Project Description

Although, this unique course project was conducted with students from five universities, this thesis focuses on the communication and deliverables from UW students only. UW students participated in this research and worked with students from IIT Madras. Each school was responsible for the school-specific module, and the team project was a combination of the school-specific modules that reflected the school represented on the team. The purpose of the project was:

1. To give the students an opportunity to increase their understanding of the practice of distributed team project management and BIM execution planning in the context of a global team,
2. To expose them to advanced tools for project collaboration and planning, and
3. To participate in a research experiment to help understand how global virtual design teams can work together effectively.

Due to the misalignment between semester and quarter schedules at each of the schools, the teams were divided into two parts. Part I students met from February to March, and Part II students met from March to May.

Part I	University of Washington (UW)	Indian Institute of Technology, Madras (IIT)
Part II	National Cheng Kung University (NCKU), National Taiwan University (NTU)	Washington State University (WSU)

Table 3: Project I schedule

Because of time constraints, this thesis focuses on the analysis of the data collected from UW students and their interaction with IIT students only (Part I only). Students from both the universities worked together on two projects:

3.4.1 - Project I

In this two-week project, students explored the addition of 3 rooms to a residential house. This house is located in Chennai, India, (the home of IIT-Madras). The owner of this house sought to add more living space to the house. The virtual team was given the task to design a small 3-room extension to an existing building and propose a construction plan for the work. The team mutually had to decide where to build the rooms (and the team could assume that structural upgrades were not needed for a single story addition, but were required for multiple story additions). In week 1 IIT modeled the 3-room addition in Revit while the UW students developed a construction schedule. The virtual team as a whole needed to decide on the additions and construction activities. In the second week, the UW team integrated the Revit model and baseline schedule to develop a 4D model in Navisworks. After completion of the 4D model a debrief of the BIM process was submitted by the UW team.

Week	Week of	Task	Deliverables
1	Feb 1, 2016	First Virtual Team Meeting 3D Model (3 room addition) Construction Schedule	3D model (revit) Construction Schedule (excel, MSProject, or P6)
2	Feb 8, 2016	4D Model Project I Debrief Meeting	4D Model (NWD + .AVI) Debrief Memo

Table 4: Project II schedule

3.4.2 - Project II

In this four-week project, students developed a BIM execution plan for the virtual team's design and construction sequence analysis of a multi-story residential building. Architectural drawings for the residential building were provided to you. This building was to be built to house people who had lost their homes in the recent floods that ravaged Chennai. As a result, virtual teams needed to think about ways in which this building could be built fast (Ideally in a few months), as well as ways in which they could reduce costs. They were guided to use BIM in order to achieve their goals. Overall, the tasks were to develop optimized 3D and 4D models for the construction of the building given the considerations above. In the first week (Week 3 in the course), the teams were allowed to reflect on their experiences in the first project and develop a BIM Execution Plan for executing Project II. A BIM execution plan consisted of timelines, templates and protocols that they could use to execute the project. The IIT-Madras team then built a 3D model in Week 4 and the UW team built a 4D model in Week 5. However, in order to ensure that project costs and duration were minimized, the UW team needed to be aware of and perhaps influence the process that the IITM team was undertaking in Week 4 and vice versa. In Week 6, the teams came together to optimize the project with a view towards presenting it to teams from NCKU, NTU and WSU in Week 7. The sharing of presentations helped the students

from other universities to better understand the whole process of global virtual collaboration. Virtual teams also prepared a short report at the end of the project highlighting

1. How the teams translated lessons learnt from Project II into your approach for Project II,
2. How the teams iterated in Project II to optimize time and cost on the project

Week	Week of	Task	Deliverables
3	Feb 15, 2016	Project II Kick-off	Draft BIM Execution Plan
4	Feb 22, 2016	3D Model Construction Schedule	3D model (Revit) Construction Schedule (excel, MSProject, or
5	Feb 29, 2016	4D Model	4D Model (NWD+.AVI)
6	Mar 7, 2016	Presentation Prep	Final Presentation
7	Mar 14, 2016	Presentation to Part II Teams	Recording of Presentation

Table 5: Project II Schedule

Total nine out of fifteen teams agreed to participate in this research work and timely submitted all the deliverables, surveys and submittals. The report and reflections from the virtual team members were also collected as a part of data collection and analyzed to spot the hidden dimension of technological leadership in virtual teams.

Participating student teams	Number of UW students on each team
Team 3	2
Team 6	3
Team 7	3
Team 8	3
Team 9	2
Team 10	3
Team 13	3
Team 14	3
Team 15	3
Total teams: 9	Total UW students: 25

Table 6: Teams participating in the research

During the analysis of the survey data, we focused on studying the overall level of collaboration satisfaction of the teams in both the projects, understanding the transition from one project to the other and finding reasons for the same along with its association with the process of technology selection. Comparing the level of satisfaction with the overcoming of communication and collaboration issues by the teams indicated the importance of technology selection in supporting the functionality of virtual teams. Further, instances from the post-project surveys were analyzed, which further highlighted the role of technology selection in supporting communication and collaboration in globally distributed virtual teams.

4 - Data Analysis and Discussion

To analyze the level of collaboration satisfaction, Likert scale was used in both the post-project surveys ranging from rating 1 (Extremely low level of satisfaction) to 7 (extremely high level of satisfaction). The level of satisfaction of most of the student virtual teams was high to very high (5-6 on a 7-point Likert scale). However, overall satisfaction level went from 76% (with rating 5 or higher) to 64% (with rating 5 or higher) from project I to project II.

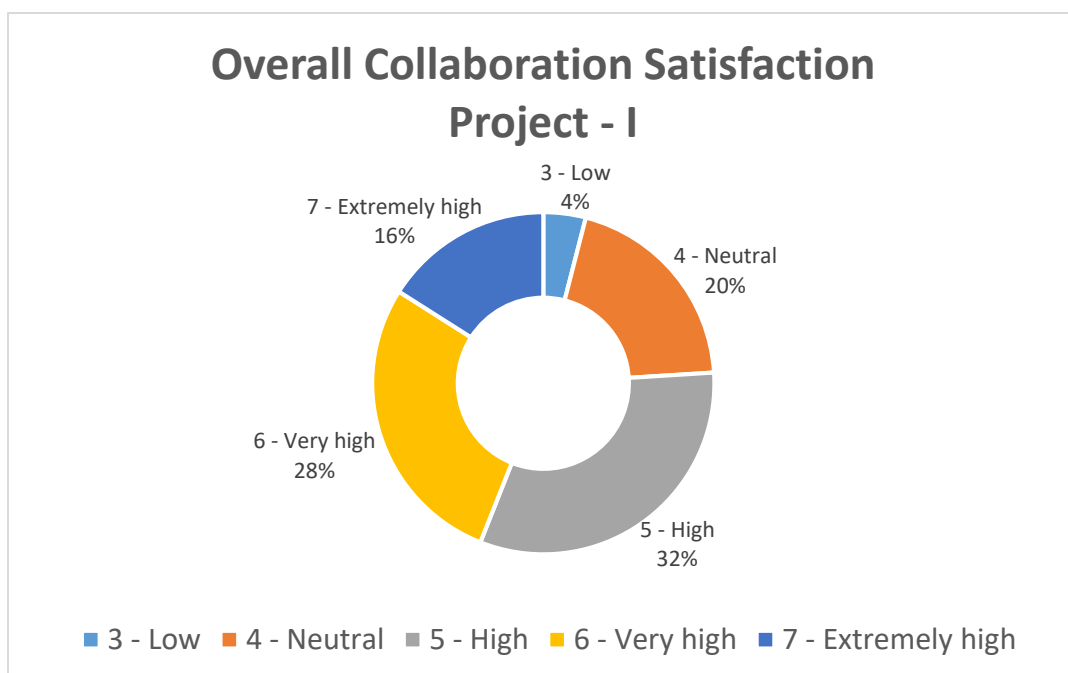


Figure 3: Overall collaboration satisfaction in Project I

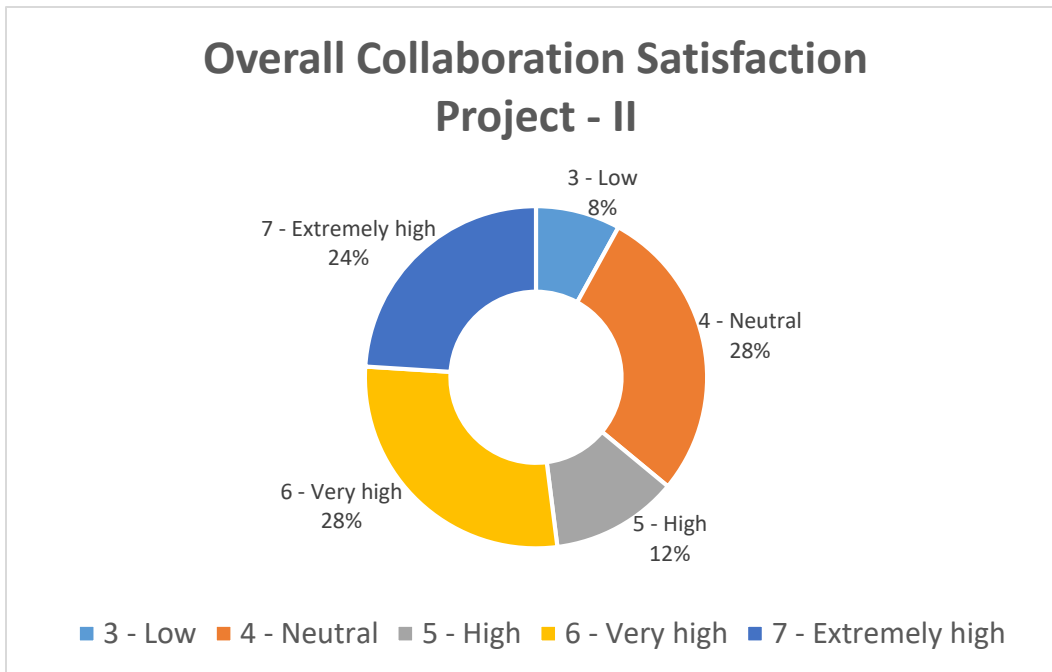


Figure 4: Overall collaboration satisfaction in Project II

Main reasons of this shift were lack of on-time delivery and promptness to correspondence (E-mails). There were a lot of last moment meeting schedule changes that were seen in the data, mainly due to the time zone difference. Miscommunication was another reason of this shift. A lot of teams reported that all the team members were not included in the mail trail leading to loss of information and communication. This is also reflected from the increase in the low level of satisfaction from 4% to 8% while transitioning from project I to project II.

Collaboration on Sococo was not cherished because of bandwidth/internet issues on the IIT side. Screen sharing feature of Sococo was not utilized at its maximum efficiency. As mentioned earlier, Sococo was being used by the teams as a 2-D virtual office environment to meet and discuss issues related to modeling and coordination. Teams reported that Sococo was not an efficient software, especially for collaborating with teams from countries where internet connectivity is poor, which in this case was true. A few teams also mentioned that they didn't even conduct one meeting in Sococo or used only the chat box feature to communicate.

Information exchange, which included minutes of meeting, Revit and Navisworks model, and project schedule was done from emails.

As a result, team members from different teams started to look for other communication and collaboration tools in order to maintain the workflow. Figure 5 shows the statistics of use of other communication and information exchange tools over Sococo during Project I itself.

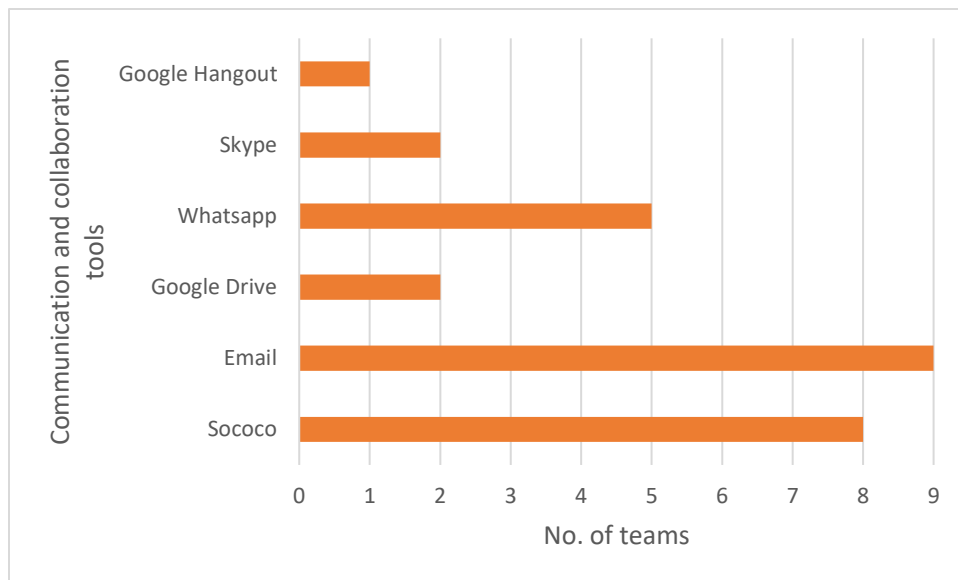


Figure 5: Sococo alternatives used by various teams during Project I

During project II, it was observed that the use of Sococo drastically went down in many teams because it was not serving its purpose. Teams learned from Project I about the drawbacks of using Sococo and used other available alternatives. Teams were only using Sococo for screen sharing, which also was not that effective due to connectivity issues. Figure 6 shows the statistics of use of other communication and information exchange tools over Sococo during Project II.

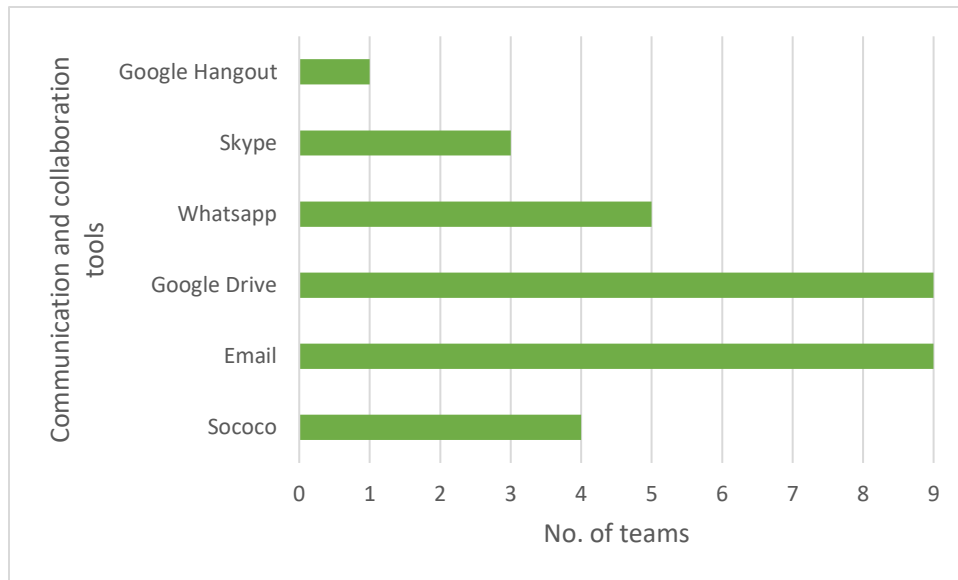


Figure 6: Sococo alternatives used by various teams during Project II

It is clear from the above figures that use of Sococo went down from being used by eight teams in project I to four teams in project II, which means that teams didn't find Sococo to be the most efficient software to coordinate and communicate with the IIT students. It is also noted that there was an increase in the use of skype as an alternative to Sococo video conferencing and google drive for effective information exchange. Google drive also helped the teams to share bulky files like the Revit models in a more organized manner. A constant use of WhatsApp indicates that it is a very efficient communication tool and should be used more to keep all team members connected and on the same page.

		Team 15	Team 14	Team 13	Team 10	Team 9	Team 8	Team 7	Team 6	Team 3
Project I	Used Sococo	○	○	○	○	●	○	○		●
	Used WhatsApp			●	●		●	●	●	
	Used Skype		○	●						
	Used Google Hagnout	●								
	Used Emails	●	●	●	●	●	●	●	●	●
	Used Google Drive			●			○			
	Faced modeling issues	●	○	○		○	●		●	●
	Faced issues due to cultural differences								○	
	Faced issues due to time difference	●	●	○	●	●	○	●	●	●
Project II	Used Sococo			○		●	○			●
	Used WhatsApp			●	●		●	●	●	
	Used Skype		○	●			●			
	Used Google Hagnout	●								
	Used Emails	●	●	●	●	●	●	●	●	●
	Used Google Drive	●	●	●	●	●	●	●	●	●
	Faced modeling issues	●	○	●	○	●			○	●
	Faced issues due to cultural differences									
	Faced issues due to time difference	●	○	○	●	●	○	○	○	●

Legend	
Never	
Frequently	●
Rarely	○

Table 7: Truth table analysis

Truth table analysis (Table 7) was also conducted to present the idea of using alternate technologies due to existing communication, collaboration and coordination issues in the

distributed virtual setup. This further indicates the team members' desire and initiatives to use new technology and be able to come up as leaders to find solutions to the problems associated with communication and collaboration.

Some teams experienced an increase in the level of satisfaction while working from project I to project II due to the use of these advanced technologies. A couple of team specific cases was studied thoroughly to understand the importance and emergence of technological leadership within the teams.

4.1 - Case 1: Team 6

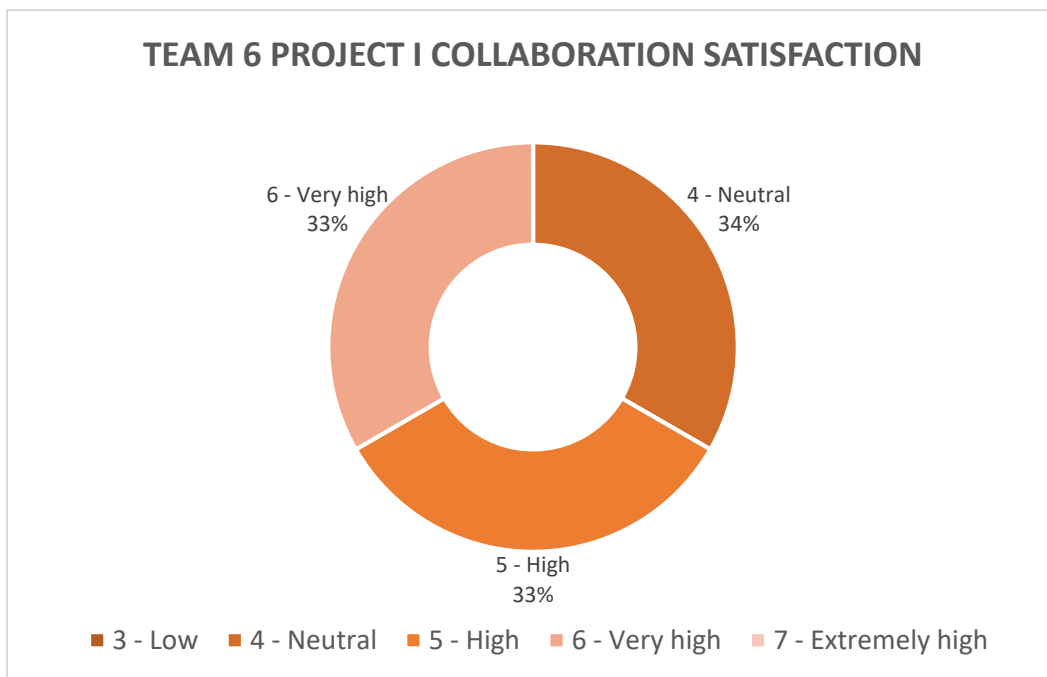


Figure 7: Team 6 collaboration satisfaction in Project I

The level of satisfaction for Team 6 went from an average to a very high level of collaboration satisfaction. Figure 7 shows the level of satisfaction of the team after finishing project I. It is clear from the above figure that there was a mixed team reaction on the level of satisfaction in project I. Data revealed that the team was trying to understand the concept of virtual team

collaboration, started to develop trust and broke the ice by interacting with IIT students during project I. This team didn't have Sococo meetings as they couldn't connect with the IIT students due to internet connectivity and bandwidth issues. But, this team reportedly used WhatsApp, a mobile phone application used to exchange texts, voice messages, photos, and videos, to communicate with the IIT students. One of the students on this team came up with the idea of using WhatsApp instead of Sococo as it helped the team communicate and share information more efficiently. This application became a platform to connect everyone on the team. It also allowed users to see who had seen the shared media and who hadn't. In this way, the team was able to check on those team members who were not as active as the other students on the team. A team member quoted in the survey, "WhatsApp will be quick and easy to communicate along with the voice recording tool. Internet is slow in IIT so using Sococo might bring up some communication issues". This indicated the emergence of a technologist in the team who dedicated him/herself in finding a solution to the issues of communication and collaboration, finding an alternative to the existing technology in use, bringing up technological innovation in the workflow and technologically aiding to the effort of collaborative team work.

Figure 8 shows the level of satisfaction of the team after finishing project II. It is seen that the level of satisfaction went to a very high level as compared to project I.

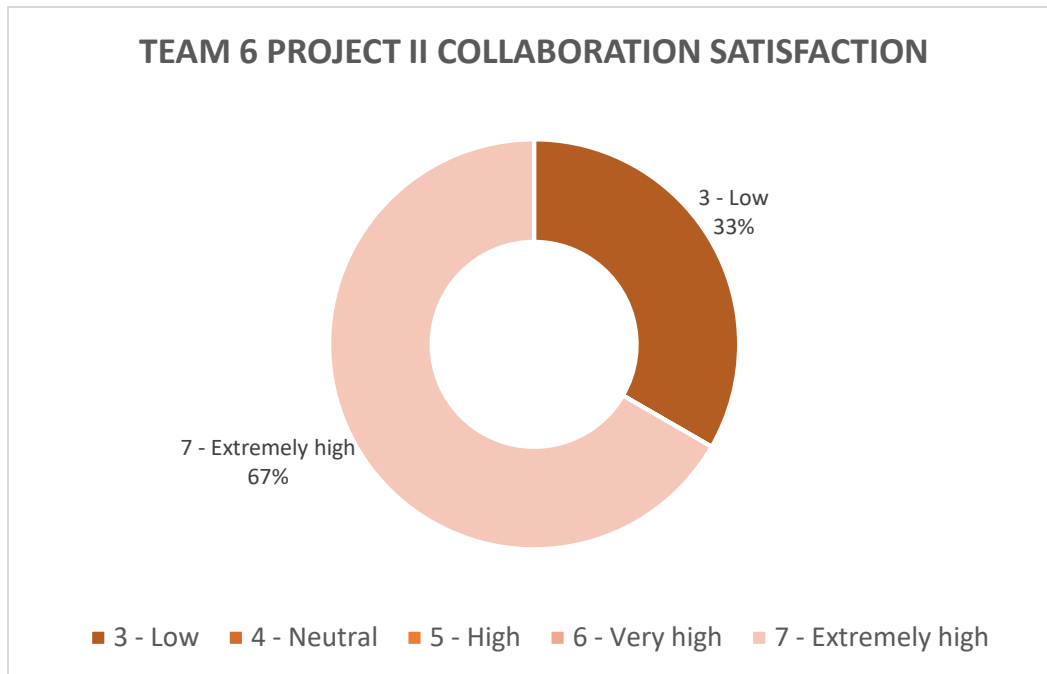


Figure 8: Team 6 collaboration satisfaction in Project II

It is evident that the satisfaction level increased due to a lot of factors, one of them being the use of newer technology to communicate, like WhatsApp. Another student in the team mentioned in the survey that, “Communication was observed to be better than project I, the communication is more efficient this time. Collaboration is very interesting and applying the theory into practice is very exciting.”

This further indicated that the communication and collaboration satisfaction of team was highly supplemented by the selection of a better technology for communication and collaboration. The emergence of a technological leader in the team was the result of having communication and collaboration issues associated with the information and communication technology in use. Thus, it can be stated that technology selection plays a very important role in supporting communication and collaboration in globally distributed virtual teams. Selecting a better technology helps the team to function in a much smoother way by enhancing the technological interactions within the team members.

4.2 - Case 2: Team 13

The level of collaboration satisfaction for team 13 was extremely high in both the projects. One of the reasons for such a high level of satisfaction in the initial stage of project I was due to the immediate adoption of new information and communication technologies.

Similar to the earlier case, this team was not able to use Sococo at its maximum efficiency due to internet and connectivity issues. As mentioned by one of the students on the team in the survey, “IIT faced connectivity issues during the night (during the daytime the network quality was satisfactory), which caused some of the meetings to be unsuccessful and as a result be postponed. Understanding this limitation at the beginning of the project helped our team to plan the meetings accordingly and avoid the time lost at initial stages of the project due to problem in connection quality”. Another student said, “Besides Sococo, our team used email, skype and WhatsApp. WhatsApp is the most frequently used communication tool in Project I because we can almost get direct response from each other.” He/she further mentioned, “We managed the communication tool issues by using Sococo, Skype, email and WhatsApp in combination. When it comes to arranging meeting, we would use WhatsApp first because in this way we could get responses more quickly”. In other words, to avoid the unsuccessful meetings on Sococo, the team found the need to switch to or use a better technology (like Skype, WhatsApp) that serves the purpose of efficient communication and provides a better collaboration platform.

While working in project II, the collaboration became stronger and the team was able to translate issues faced in project I to solutions for project II. A student quoted in the survey, “First, everyone in the project have committed himself/herself to making a significant contribution to delivering the project with higher quality and each member played a key role in the accomplishment of the project. Next, an atmosphere of trust, respect, and collaboration has been

established among project members. Last but not least, various collaboration tools were used in conjunction with each other, which increased the efficiency of communications. I liked the way web-based collaboration tools facilitated project communications”. Another student mentioned, “Don't limit yourself to one collaboration tool. Start using multiple tools in the beginning of project itself”.

This clearly portrays that the team members were actively looking for a better collaboration technology from the time they realized that the existing technology in use was restraining them from communicating and collaborating within themselves. This is a pure indicator of the fact that there were team members who emerged as technological leaders to support their team in all ways possible by finding solutions to the technical issues in collaboration and communication. They came forward with ideas of using better collaboration tools, in the beginning of the project itself, in order to maintain the effective workflow. It is evident that technology selection pushed forward the team to reach their goal by understanding the technological constraints at the very beginning and finding solutions to those constraints.

In general, a lot of teams were satisfied with the use of new technology for collaboration and communication. However, it is important to mention that not all teams experienced an increase in the level of collaboration satisfaction from project I to project II even after having new technology deployed at the beginning of project II. But, it is also not correct to blame the interference of new technology for not having a high level of satisfaction. It was observed in the survey analysis that teams were satisfied with the adoption of newer technology but were not satisfied because of issues like time constraints, tight schedules, limited knowledge of modeling tools and unnecessary delays. The teams were working in a time crunch from the beginning of project I. The team members couldn't find time to address all the issues in the 3D and 4D

models. One student mentioned in the survey, “We experienced problems with getting deliverables done on time to start the project. The teammates at IIT needed more time to do the project so that they would have time to make edits. email and WhatsApp worked well for communication and collaboration but not overcome this time crunch”. Another student said, “We talked about exploring a different tool for the 2nd project after the problems we had with Sococo in project I” even though, they ended up with a lower level of satisfaction in project II.

This indicated that there are other factors, which may or may not be associated with technology, that affect the process of collaboration even after adopting new technology. It definitely showed that correct technology selection supported the teams in reducing communication issues and providing a better platform for collaboration but at the same time, the technology couldn't guarantee a successful transition from one stage to other, because of other factors that come into role.

It can, therefore, be said that technology selection plays a very crucial role in supporting collaboration and communication in globally distributed virtual teams. Technology related issues that exist in the team push the team members to take the position of technologists who can find solutions to those issues up front, in order to provide uninterrupted communication and information exchange. While working in a collaborative virtual environment, team members start to feel the need of using newer technology in the course of time in order to facilitate communication, coordination and collaboration. Hence, they begin to act as technological leaders who bring forward the ideas of using and selecting advanced information and communication technologies, and also help in training the team members in learning the new technology.

5 - Conclusions and Future Research

This research project aimed at producing results, which supported the importance of selection of the most appropriate technology for collaborating and communicating in globally distributed virtual teams. It was observed that the existing technology related issues gave rise to the selection of a newer technology within the virtual teams, which benefited the team in the overall process of communication and collaboration.

The findings from this thesis indicated that:

- 1) As mentioned by Iorio and Taylor (2015), in addition to engagement in transactional and transformational interactions, effective leaders must also engage in technological interactions. This notion was very well supported by the data analysis of the post-project survey data (Section 4).
- 2) Due to existing issues in technology, team members start to feel the need of trying/using a newer technology to provide a better communication and collaboration platform to the team. Few of them come up as technological leaders who suggest the ideas of using advanced communication and collaboration technologies to maintain unrestricted workflow and rich information exchange.
- 3) Technology selection plays a vital role in supporting collaboration and communication in globally distributed virtual teams. It reduces the communication and coordination issues within the team by providing better means of communication and collaboration. It provides a platform to the team members to stay connected and be on the same page. It further supports the idea of strengthening parameters like relationship building, trust, training, etc. that govern the functionality of virtual teams.

This study was limited to the discovery of the importance of technology selection for the virtual teams. It concentrated on finding the technical issues, which occur while working with a communication and collaboration tool and later, finding better or more appropriate technology to improve the communication and collaboration between the virtual team members. It couldn't study other issues that affect the functionality of virtual teams and couldn't establish its connection with the selection of new technology to communicate and collaborate. The next steps in the course of this work would be to find out if, in some way, technology selection can deal with issues like time constraints, tight schedules, limited knowledge of modeling tools and unnecessary delays or not. It will be really useful for the future researchers to investigate and navigate through the involvement of technology selection in such issues that currently have not been explored a lot. Further, correlation between BIM execution planning and technological leadership can be studied by comparing the level of collaboration satisfaction of the teams to the effective implementation of the BIM execution planning. This will enhance the scope of study on technology and leadership in general and will provide an amazing correlation with the current study.

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Appendix A – Survey Questionnaire

Q1. Please fill out the table for each meeting you have had with your team:

Date	Start Time	End Time	Communication tools	Participants	Agenda

Q2. What other types of communication have you had? (e.g. email) Describe the frequency and content of the communication.

Q3. What is your overall satisfaction with your team collaboration? (Use Likert Scale)

1 - Extremely Low

2 - Very low

3 - Low

4 - Neutral

5 - High

6 - Very High

7 - Extremely High

Q4. Explain your ranking for question 3 - why do you rank your satisfaction this way?

Q5. Tell us things you like about the global team project.

Q6. What difficulties have you experienced?

Q7. What suggestions do you have to improve the communication and collaboration with your team? Mention other communication methods and communication tools, if used.

Q8. What are your lessons learned to date?

Q9. What advice do you have for the students who take this class next year?