AN ABSTRACT OF THE THESIS OF

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Title: The Impact of Shared Ownership on Virtual Team Effectiveness

Abstract approved:

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Toni L. Doolen

This research studied the role of shared ownership on virtual team effectiveness, using student teams enrolled in engineering management coursework at Oregon State University and Virginia Polytechnic Institute. After a thorough review of the literature, the concept of shared ownership was developed. This concept was operationalized as the extent to which virtual team members believe they are equally responsible and accountable for project deliverables in which all team members receive the same evaluation.

This research appears to be one of the first to examine the influence of shared ownership on multiple measures of team effectiveness. To evaluate the effects of shared ownership on virtual teams, two studies were performed. In the first study, team processes believed to be affected by shared ownership were investigated. These processes included team resource utilization and the establishment of shared mental models. In this study team performance was measured using an objective measure and perceptual-based survey measure. Team member satisfaction was also measured. The first study was also used to help develop, test and validate a survey instrument for measuring team processes related to resource utilization and the development of shared mental models. In the second study, two different project assignments were developed in an attempt to create differing levels of shared ownership. Although the assignment failed to establish significant or measurable differences in shared ownership, the effects of resource utilization and shared mental models on team performance and team member satisfaction were studied.

Results from this research indicate that resource utilization and the development of shared mental models are highly correlated to each other, and that both of the variables are related to team member satisfaction. Upon comparison of the quantitatively measured data and the qualitative material collected in both studies, it was found that the qualitative analysis was consistent with the quantitatively data. On only two occasions out of 15 was qualitative evidence inconsistent with the survey data.

Implications from this research extend to both practitioners and to the governing body of knowledge on virtual teams. Based on the findings from this study, engineering managers should ensure that support systems and activities are in place to help virtual teams utilize resources or develop shared mental models. These activities should increase team member satisfaction. The findings from this study also support the need for researchers to further develop and understand the concept of shared ownership and its implications on virtual team processes and performance.

The Impact of Shared Ownership on Virtual Team Effectiveness

by
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I understand that my thesis will become part of the permanent collection of Oregon State University libraries. My signature below authorizes release of my thesis to any reader upon request.

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Mark A Bonnono, Author

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The Impact of Shared Ownership on Virtual Team Effectiveness

1 Introduction

Advances in communication technology have made the ability to communicate and function across physical boundaries a reality. Many organizations are taking advantage of this opportunity by employing the use of virtual teams. The term virtual team has been defined in a variety of ways by different researchers. Table 1 summarizes six definitions that are representative of definitions found in the literature.

Table 1

Different Virtual Team Definitions taken from literature

Virtual Team Definition	Source
"A project team that rapidly forms, reorganizes, and dissolves when the needs of a dynamic marketplace change; and made up of individuals with differing competencies who are located across time, space, and cultures."	Jarvenpaa & Leidner (1999, p.791)
"Globally distributed people who collaborate on issues and challenges facing a company at the international level."	Maznevski & Chudoba (2000, p.473)
"Groups of people with a common purpose who carry out interdependent tasks across locations and time, using technology to communicate much more than they use face-to-face meetings."	Cramton (2001, p.346)
"Teams that are dispersed (carried out in different place) and work asynchronously (carried out at different times)."	Montoya-Weiss, Massey, & Song (2001, p.1251)
"Groups of geographically and/or organizationally dispersed coworkers that are assembled using a combination of telecommunications and information technologies to accomplish an organizational task."	Townsend, DeMarie, & Hendrickson (1998, p.18)
"Geographically distributed knowledge workers who collaborate on a variety of workplace tasks."	Warkentin, Sayeed, & Hightower (1997, p.975)

Common to all virtual team definitions is the idea that virtual teams are groups composed of individuals who collaborate over time, space, and distances, using information technologies (such as email or audio/video conferencing) to achieve a common goal. Virtual teams are not only defined differently by various researchers but they are also referred to using different terms. For example Cramton (2001) uses the term 'dispersed collaboration,' whereas, Hinds & Bailey (2003) use the term 'distributed team' to refer to

a virtual team. Some other terms used interchangeably with the term ‘virtual team’ is ‘global team’ and ‘computer-supported team’ (Chidambaram, 1996; Solomon, 1995).

Virtual teams offer organizations the ability to enter new markets, work closer with outsourced partners, and leverage project teams whose members span physical, temporal, organizational and cultural boundaries (Leinonen, Jarvela, & Hakkinen, 2005; Maznevski & Chudoba, 2000). Likewise, virtual teams have also been utilized to accomplish tasks critical to the core business and core operations of an organization (Pauleen & Yoong, 2001; Leinonen et al., 2005). It is not uncommon to find organizations that rely heavily on virtual teams for key operations, including product development, strategic analysis, and customer service (Maznevski & Chudoba, 2000; Hertel, Geister, & Konradt, 2005; Jarvenpaa & Leidner, 1999; Sarker & Sahay, 2003; Kanawattanachai & Yoo, 2007).

1.1 Motivation

Although virtual teams may offer organizational advantages over traditional teams, they also create new challenges. Virtual teams interact primarily through the use of computer mediated communication technology. These technologies, although advanced, often limit the information that can be transferred during an exchange. Loss of social cues, for example, during communication and the inability of virtual team members to have unplanned, informal discussions are two examples of situations that can hinder a virtual team’s ability to perform effectively and efficiently (Lee-Kelly, Crossman, & Cannings, 2004). Barriers to virtual team performance, identified in the literature, can be classified into five categories: trust barriers, cultural barriers, technological barriers, ineffective leadership, and barriers to the establishment of shared mental models.

The establishment of trust between virtual team members is the most frequently cited barrier within the existing literature on virtual teams. Barriers to the development of trust between virtual team members is derived from a lack of previous experience and/or knowledge about virtual team members, loss of peripheral cues about team member

reactions to discussions, and the electronic mediation of communication. In addition, team level factors, such as role ambiguity, can also inhibit the development of trust between virtual team members (Dani, Burns, Backhouse, & Kochhar, 2006; Malhotra, Majchrzak, & Rosen, 2007; Jarvenpaa, Shaw, & Staples, 2004).

Technology barriers can take many forms including lost context, improper technology use, and unreliable technology (Liz et al. 2004). Cultural barriers arise when virtual teams must complete their work across cultural boundaries. Cultural barriers may arise from teams that function across different professional cultures, national cultures or organizational affiliations (Maznevski & Chudoba, 2000; Chudoba, Wynn, Lu, & Watson-Manheim, 2005; Hardin, Fuller, & Davison, February 2007).

The development of a common understanding of the team's goals and objectives is more difficult in virtual teams than for co-located teams. This common understanding is created through the establishment of processes and systems that allow members to keep track of information about each other. This information includes processes for communicating team member skills, unique team member contributions, as well as the status of work in progress. When shared mental models do not exist, team performance can be negatively impacted. An example consequence would be the underutilization of team member knowledge and skills (Sivunen & Valo, 2006).

Virtual team leaders are influential in a virtual team's development. Because team leaders have control in determining the technology the team uses, establishing the culture in which the team operates, facilitating trust, and facilitating shared mental models, team leaders are critical to the success of a virtual team. Team leaders who fail to recognize, acknowledge, and take steps to circumvent prevalent problems known to affect virtual team performance can compromise team performance (Sivunen & Valo, 2006).

The challenges faced by virtual teams are significant. The increased use of virtual teams within organizations, coupled with the many unique challenges virtual teams face has

created an urgency for research on the factors that can affect virtual team performance (Cramton, 2001; Hertel et al., 2005; Jarvenpaa & Leidner, 1999; Townsend et al., 1998). The continuing development of technology also adds urgency to the need for up-to-date research. Such research can provide important information for virtual teams on how to best leverage and adapt to the limitations and potential that new technology offer (DeSanctis & Poole, 1994; Guo, D'Ambra, Turner, & Zhang, 2009; Hinds & Bailey, 2003; Townsend et al., 1998).

1.2 Contribution

An industrial engineer can be defined as "one who is concerned with the design, installation, and improvement of integrated systems of people, material, information, equipment, and energy by drawing upon specialized knowledge and skills in the mathematical, physical, and social sciences, together with the principles and methods of engineering analysis and design to specify, predict and evaluate the results to be obtained from such systems" (Salvendy, 2001, p. 5). It can also be said that industrial engineering is built off a core engineering curriculum foundation and then specializes into four basic areas: human factors engineering, manufacturing systems engineering, operations research, and management systems engineering (Salvendy, 2001). This research directly adds to the scholarly body of knowledge in the area of management systems engineering.

A variety of researchers have identified and studied multiple facets related to the performance and effectiveness of virtual teams. However, one area that is not well developed in the current body of knowledge is how sharing ownership on project deliverables can affect teamwork and a virtual team's ability to effectively perform. This research contributes to this body of knowledge by identifying and studying the impact of three different variables on the performance of virtual teams, using real teams.

1.3 Research Hypotheses

In order to understand the effects of establishing shared ownership within a virtual team, the research question guiding this study was, "what is the impact when virtual teams establish different levels of shared ownership on a project deliverable, undertaken in the early stages of the project?" More specifically, what are the effects, if any, of establishing shared ownership among virtual team members on the virtual team's resource utilization, the development of shared mental models, team performance (both objectively and subjectively measured), and team member satisfaction.

The independent variable tested in this study was shared ownership. Shared ownership was operationalized as the extent to which virtual team members believe they are equally responsible and accountable for a project deliverable in which they receive the same evaluation[1]. In an attempt to create different levels of shared ownership between different virtual teams, two different team charter assignments were used. A team charter is a written document that defines a variety of behavioral and performance expectations and team member information including team member skills, ground rules, and team standards for availability. Other information deemed applicable to the effective and efficient functioning of a team is also included in the charter document. A charter document was chosen as the intervention mechanism because it is developed by a team at the beginning of a virtual team's life.

The mediating variables of the study were resource utilization and shared mental models. The dependent variables were team performance and team member satisfaction. Resource utilization was operationalized as the extent to which a team effectively utilizes key resources, including team member knowledge. Shared mental models were operationalized as the degree to which team members have a common understanding of the team's objectives/goals, as well as a strategy for reaching the objectives/goals. Team performance was operationalized as the quality of work a virtual team produces. This was

1. After the completion of this study, it was realized that the definition of shared ownership did not adequately reflect the author's intent. This is discussed further in Chapter 5.

measured in two ways, objectively and subjectively. Objective team performance was operationalized as the final evaluation each virtual team received upon completion of the final project deliverable. Subjective team performance was operationalized as an aggregated team member evaluation of the quality of the team's work, also measured at the completion of the team's final project deliverable. Team member satisfaction was operationalized as an aggregated team member evaluation of individual satisfaction resulting from the virtual team experience.

The hypothesized relationships between these independent, dependent, and mediator variables are illustrated using two path diagrams, shown in Figure 1. Each arrow (or path) on the diagrams represents a research hypothesis. Each of the hypotheses represented graphically in Figure 1 are summarized in Table 2.

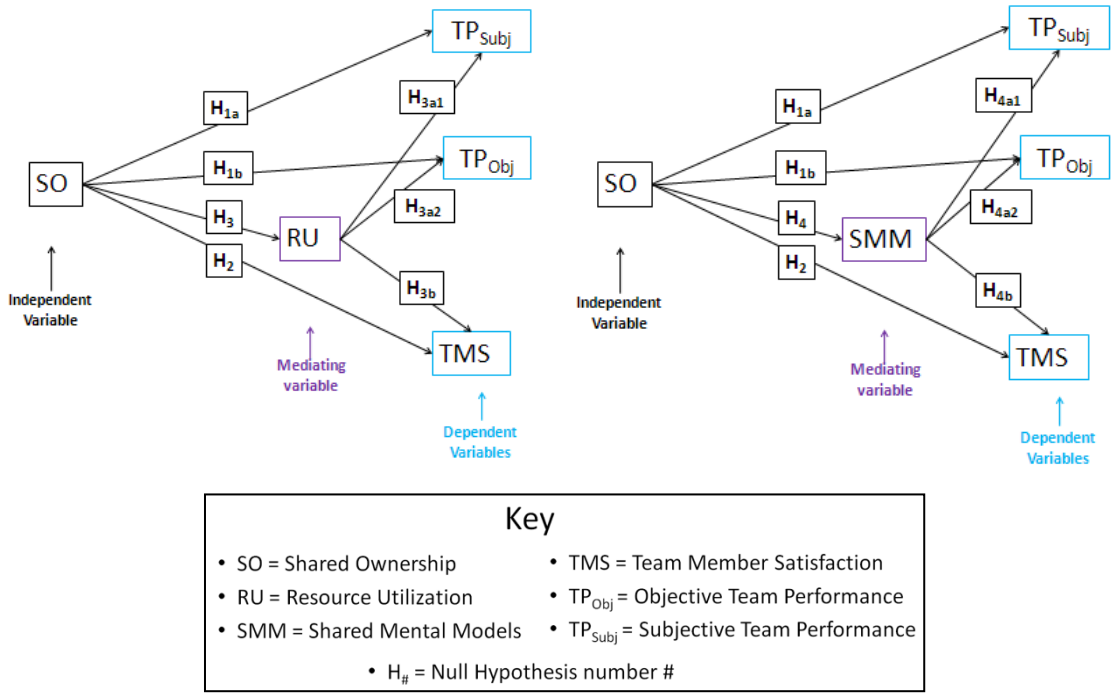

Figure 1: Hypothesized relationships represented by two path diagrams

Table 2

Research Hypotheses

H_{1a}: Shared Ownership has a direct relationship with Subjective Team Performance
H_{1b}: Shared Ownership has a direct relationship with Objective Team Performance
H_2: Shared Ownership has a direct relationship with Team Member Satisfaction
H_3: Shared Ownership has a direct relationship with Resource Utilization
H_{3a1}: The relationship between Shared Ownership and Subjective Team Performance is mediated by Resource Utilization
H_{3a2}: The relationship between Shared Ownership and Objective Team Performance is mediated by Resource Utilization
H_{3b}: The relationship between Shared Ownership and Team Member Satisfaction is mediated by Resource Utilization
H_4: Shared Ownership has a direct relationship with Shared Mental Models
H_{4a1}: The relationship between Shared Ownership and Subjective Team Performance is mediated by Shared Mental Models
H_{4a2}: The relationship between Shared Ownership and Objective Team Performance is mediated by Shared Mental Models
H_{4b}: The relationship between Shared Ownership and Team Member Satisfaction is mediated by Shared Mental Models

1.4 Methodology

To study the effect of shared ownership on virtual team performance and team member satisfaction, both a qualitative and a quantitative study were undertaken. The research was performed in two parts; first a study was conducted in 2008. A second study was conducted in 2009. The 2008 study had two objectives. The first objective was to develop, test, and validate a survey instrument for measuring the dependent variables. The second objective of the 2008 study was to assess if the second stage of the research, i.e. the 2009 study, was worth pursuing. Data from both the 2008 and 2009 studies were used to test the relationships shown in Figure 1.

Both studies were conducted using student teams, of peers without a designated team leader. Participants were students enrolled at Oregon State University (OSU) or at Virginia Polytechnic Institute and State University (VT), and who were enrolled in an engineering management course. The students from OSU were a mixture of graduate and undergraduate students, while the students from VT were all graduate students. Virtual teams were created with these students. In both studies, the virtual teams worked on a performance measurement system design project assigned as part of the required coursework. The assignment was titled a "virtual performance measurement design project." The objective of the virtual design project was to create a performance measurement system. In both studies the project included three deliverables: an initial "target organizational system identification task," a "virtual team charter document," and an "organizational performance measurement system design report." The target organizational identification task resulted in a single email from the team to both the OSU and VT instructors describing the chosen organization. Two different virtual team charter assignments were given to students in the two studies. These documents are described in more detail next. The final deliverable of the virtual team project was an organizational performance measurement system design report. This report was composed of six sections: a "Need for Measurement" section; a "Suppliers- Inputs-Processes-Outputs-Customers Diagram" section; a "Mission Statement" section; a "Strengths-Weaknesses-Opportunities-Threats Analysis" section; a "Metrics" section; and a "Measurement System Audit" section.

In the 2008 study, each team was asked to develop a virtual team charter document, following a template. Each charter document required the virtual teams to specify, in writing, group objectives, an overview of their target organization, group processes, team roles, and principles of operation. Both quantitative and qualitative methodologies were used in the 2008 study to assess the study objectives. Quantitative data were collected after the students had completed the virtual projects. Upon completion of the virtual projects, teams were offered extra credit if the team would provide the instructors with copies of all electronic communication (i.e. chat room discussions, emails, and etc.) that

were used by the team. These documented communications were used as the dataset for a qualitative study of the relationships between resource utilization, shared mental models, team performance, and team member satisfaction.

In the 2009 study, it was hypothesized that two levels of shared ownership could be created by assigning two different team charter templates (i.e. Charter Assignment-A and Charter Assignment-B). One of the two assignments was randomly assigned to each virtual team in the study. Charter Assignment-A was the same charter template assigned to all the virtual teams in the 2008 study. Charter Assignment-B forced teams to document more details related to team processes than Charter Assignment-A. It was intended that the additional details/work required in completing Charter Assignment-B would increase the team's level of commitment to each other, the project and team motivation.

Table **3** lists the requirements of both charter assignments. All members of a team received the same score for the charters. The quantitative data was collected using a survey that was administered after virtual teams had completed the assigned project. Qualitative data were gathered by asking students to provide copies of any electronic communications to either the OSU or VT instructor. In the 2009 study, no extra credit was given to teams who provided copies of electronic communications.

Table 3

Requirements of Charter Assignment-A and Charter Assignment-B

Charter Assignment-A	**Charter Assignment-B**
• an overview of their selected organization • group objectives • group processes • team roles • principles of operation	• an overview of their selected organization • team goals • team ground rules • complete individual skills inventories • identify potential barriers and establish coping strategies • conflict management strategies • standards for availability • identify personality types and or learning styles for each team member

1.5 Results

The attempt to create different levels of shared ownership within this research was unsuccessful. However, the results from this research indicate that resource utilization and the development of shared mental models are highly correlated to each other, and that both of the variables are related to team member satisfaction. Upon comparison of the quantitatively measured data and the qualitative material collected in both studies, it was found that the qualitative analysis was consistent with the quantitatively measured data. On only two occasions out of 15 was qualitative evidence inconsistent with the survey data.

Implications from this research extend to both practitioners and to the governing body of knowledge on virtual teams. Based on the findings from this study, engineering managers should ensure that support systems and activities are in place to help virtual teams utilize resources or develop shared mental models. These activities should increase team member satisfaction. The findings from this study also support the need for researchers to

further develop and understand the concept of shared ownership and its implications on virtual team processes and performance.

2 Literature Review

The literature reviewed for this study represented a broad range of disciplines, was published for both practitioners and researchers, and offered the largest or most current contributions to the body of knowledge on virtual team performance and virtual team member satisfaction. Thirty articles on virtual teams were originally obtained. All of the references listed in the thirty original articles were captured. Google Scholar (i.e. http://scholar.google.com) was used to determine the number of times each article had been cited since its publication. Appendix A summarizes all of the articles referenced in this chapter along with the number of times each article had been cited since publication.

Some of the key words used in the search for related literature included: virtual teams, distributed teams, and dispersed teams. Some of the key words used in the search for literature related to shared ownership were: shared ownership, shared responsibility, and shared evaluations. The key words used in the search for literature addressing resource utilization were: resource utilization, knowledge management, knowledge sharing/transfer, and knowledge coordination. The words used in the search for literature addressing shared mental models were: shared mental models, shared understanding, common identity, and collective identity. Literature that elaborated on team charters was also reviewed. Some of the key words used in the search for literature on team charters were: team charter, project charter, and group charter.

2.1 Introduction to Virtual Teams

As a result of increased globalization, heightened competitive pressures, and the tendency of organizations to rely on teamwork to solve complex problems, team members are collaborating more and more from distant locations, using virtual teams (Hertel, Konradt, & Orlikowski, 2004; Kayworth & Leidner, 2000; Hinds & Bailey, 2003). Recent results in organizational studies have shown that virtual teams are assigned to some of the most important tasks in innovative, knowledge-intensive organizations (Leinonen, Jarvela, & Hakkinen, 2005; Maznevski & Chudoba, 2000). Economic developments, including

deregulation of product and service industries, together with the growth of an interdependent global economy have also fueled the growth of virtual teams (Cascio & Shurygailo, 2003; Hinds & Bailey, 2003). Today it is not uncommon to find an organization that relies heavily on virtual teams to perform key business functions, including product development, strategic analysis, and customer service (Maznevski & Chudoba, 2000; Hertel et al., 2005; Jarvenpaa & Leidner, 1999; Sarker & Sahay, 2003; Kanawattanachai & Yoo, 2007). In 2004 the *Wall Street Journal* reported that more than half of companies with more than 5000 employees used virtual teams. A similar survey by the Gartner group, also completed in 2004, found that more than 60% of professional employees work in virtual teams (Martins, Gilson, & Maynard, 2004).

Virtual teams offer organizations the ability to leverage an organization's best talent, capitalizing on a virtual team's innate ability to create functioning teams who collaborate together across time, space, and distances (Cascio & Shurygailo, 2003; Solomon, 1995; Townsend et al., 1998; Martins et al., 2004; Maznevski & Chudoba, 2000; Cascio, 2000). Virtual teams provide an effective structural mechanism for handling the increased travel, time, coordination, and costs associated with bringing together geographically, temporally, and functionally dispersed employees to work on a common task (Martins et al., 2004; Maznevski & Chudoba, 2000; Cascio & Shurygailo, 2003; Cascio, 2000). Further, to attract and retain employees, knowledge workers in particular, organizations are increasingly offering remote working options to employees (Cascio, 2000; Martins et al., 2004; Maznevski & Chudoba, 2000; Vlaar, Van Fenema, & Tiwari, 2008).

2.1.1 *Virtual Team Challenges and Barriers*

Despite the burgeoning demand for virtual teams, the complex processes governing how virtual teams develop over time are inadequately understood (Sarker & Sahay, 2003). Unlike more traditional face-to-face teams, virtual teams must meet additional challenges, such as networking, self-management, and interpersonal awareness, among other challenges that arise from using new and evolving communication technologies

(Rutkowski, Saunders, Vogel, & Van Genuchten, 2007; Duarte & Snyder, 1999; Solomon, 1995). In this section the literature referencing challenges or barriers to virtual team success is discussed. Literature indirectly referencing challenges and barriers that a virtual team may face are discussed in Section 2.4.2 "Critical Factors."

The barriers that virtual teams face can be classified in one of two ways. In the first classification five categories of barriers have been developed. These are barriers to the development of trust, technological barriers, cultural barriers, barriers to the establishment of shared mental models, and leadership/management challenges (Distefano & Maznevski, 2000; Martins et al., 2004; Duarte & Snyder, 1999; Powell, Piccoli, & Ives, 2004). The second classification again divides the barriers into five categories and is very similar to the first classification. Trust, technology and leadership/management all remain as categories of virtual team barriers. The only changes are with cultural barriers and barriers to shared mental models, which are replaced by the categories: communication barriers and collaboration barriers (Kayworth & Leidner, 2000; Kayworth & Leidner, 2002; Paul, 2006; Leinonen, Jarvela, & Hakkinen, 2005).

Both classifications address the same fundamental problems facing virtual teams, only through different lenses. For example in the first classification, challenges due to loss of social and context cues are attributed to technology barriers, whereas in the second classification the lack of social cues are attributed to communication barriers. In the second classification, cultural differences get attributed to both communication barriers and coordination barriers. The first classification scheme was used to organize this review of related literature.

The establishment of trust between virtual team members is one of the most significant barriers a virtual team must overcome (Jarvenpaa, Knoll, & Leidner, 1998; Piccoli & Ives, 2003; Wilson, Straus, & McEvily, 2006; Kirkman, Rosen, Gibson, Tesluk, & McPherson, 2002).

Table 4 presents a list of the factors commonly associated with the causation of trust issues within a virtual team.

Table 4

Factors associated with the development of trust issues in virtual teams

Contributing Factors - Lack of Trust	Cascio (2000)	Coppola, Hiltz, & Rotter (2004)	Jarvenpaa et al. (1998)	Kirkman et al. (2002)	Piccoli & Ives (2003)	Powell et al. (2004)	Vlaar et al. (2008)	Wilson et al. (2006)	Peters & Karren (2009)
Diminished verbal and non-verbal cues associated with communicating through computer mediated technologies		X	X	X	X	X	X	X	
Lack of synergy that commonly develops in face-to-face teams	X		X						X
There is more uncertainty and risk		X	X	X		X		X	
Lack of team member visibility and visibility of team member contributions	X	X	X		X		X		
Lost context during communication		X	X	X			X	X	
Unfamiliarity with teammates			X		X	X			
The lives of most virtual teams are relatively limited			X		X	X		X	X

Technology barriers are the most frequently cited challenge facing a virtual team. These are issues that arise from the use of computer-mediated communication tools. Table 5 presents a list of the factors associated with technological challenges facing virtual teams.

Table 5

Factors associated with technological challenges facing virtual teams

Contributing Factors- Technology barriers	Fiol & Orlikowski (2004)	Guo et al. (2009)	Hinds & Bailey (2003)	Hertel et al. (2004)	Kayworth & Leidner (2000)	Kayworth & Leidner (2002)	Leinonen et al. (2005)	Martins et al. (2004)	Montoya-Weiss, Massey, & Song (2001)	Paul (2006)	Powell et al. (2004)	Warkentin, Sayeed, Hightower (1997)
A reliance on technology to communicate		X	X		X	X	X	X	X	X		X
Traditional social mechanisms are lost or distorted due to the technological work environment	X	X			X	X	X	X	X	X	X	X
Differences in salience and interpretation of written text		X			X	X	X				X	X
Increased feelings of isolation due to the technological work environment	X			X								
Increased chances of misunderstandings and conflict escalation due to the technological work environment			X	X								
Increased opportunities for role ambiguity		X		X	X	X						
Feelings of technophobia					X							
A need for team members to be proficient using a wide range of technologies					X	X						
The ability to develop relational links may be hindered					X	X			X			
Participants may not have common orientations and reference points	X						X				X	
Collaborative environments are difficult to create and support							X			X		

Cultural barriers arise when virtual teams must complete their work across cultural boundaries. Cultural boundaries can take the form of professional cultures, national cultures or organizations affiliations (Maznevski & Chudoba, 2000; Duarte & Snyder, 1999; Distefano & Maznevski, 2000). Cultural differences can lead to coordination

difficulties (Kayworth & Leidner, 2000; Martins et al., 2004) and create obstacles to effective communication (Kayworth & Leidner, 2000). Table 6 lists factors virtual teams commonly face associated with cultural barriers.

Table 6

Factors associated with cultural challenges in virtual teams

Contributing Factors - Cultural Issues	Distefano & Maznevski (2000)	Duarte & Snyder (1999)	Kayworth & Leidner (2000)	Kayworth & Leidner (2002)	Martins et al. (2004)	Powell et al. (2004)	Solomon (1995)
Cultural values and norms are deeply held	X		X		X	X	X
Cultural values and norms are easily taken for granted	X		X	X		X	X
Communication may be distorted through cultural biases/misunderstandings			X	X	X	X	X
Cultures deepest effects on behavior and interaction are usually hidden	X						
Partners and suppliers often have conflicting goals and organizational cultures		X					
People from different functional areas frequently operate based on different rules		X					

The development of shared mental models in virtual teams is much more difficult than in co-located teams. Shared mental models result from the establishment of systems and processes by which all members keep track of information about each other. This includes processes related to developing skills inventories, identifying unique team member contributions, and tracking work in progress. Without access to this type of information, it becomes very easy for virtual team members to be underutilized and makes it more difficult for virtual team members to determine how they can best contribute to the team (Sivunen & Valo, 2006). Table 7 presents a list of the factors

commonly associated with the challenges virtual teams face in establishing shared mental models.

Table 7

Factors associated with establishing shared mental models virtual teams

Contributing Factors - Shared Mental Models	Bjorn & Ngwenyama (2009)	Crampton (2001)	Martins et al. (2004)	Powell et al. (2004)	Vlaar et al. (2008)
A diminished ability to observe team members and the work they produce	X				
A lack of mutual knowledge at the onset of the project		X		X	
More diligent team monitoring efforts are required than in co-located teams			X		
Frequently there is a lack of a shared language among team members		X		X	
Transfer & transformation of preexisting understandings is more complicated					X
Co-creation of novel understandings is more complicated			X		

A virtual team leader is very influential in a virtual team's ability to be successful. Team leaders who do not recognize, acknowledge, and take steps to circumvent prevalent problems known to affect virtual teams, put the team in an unfortunate position. Team leaders have control in determining the technology the team uses, establishing the culture in which the team operates, and in facilitating the development of trust and shared mental models within the team. Table 8 presents a list of the challenges virtual team leaders commonly face.

Table 8

Factors associated with leadership challenges faced in virtual teams

Contributing Factors –Leadership Challenges	Cordery, Soo, Kirkman, Rosen, & Mathieu (2009)	Hinds & Bailey (2003)	Hertel et al. (2004)	Hertel et al. (2005)	Jarvenpaa & Leidner (1999)	Kayworth & Leidner (2000)	Kayworth & Leidner (2002)	Kirkman et al. (20002)	Leinonen et al. (2005)	Townsend et al. (1998)
Overcoming team members' feelings of isolation and detachment			X					X		
Team members may have multiple and competing alliances outside the virtual team										X
A need to balance technical and interpersonal skills within the team			X				X	X		
Only a minimal amount of face-to-face interactions				X						
Team leader must coach from a distance	X	X	X	X		X				
A hindered ability to maintain common goals				X		X				
Increased tendencies for social loafing to occur			X		X				X	
Team members may be spread across multiple time zones	X						X			
Challenges in assessing and acknowledging performance			X	X				X	X	
Motivational challenges	X		X	X	X				X	
Increased likelihood of role ambiguity or role overload					X					

2.1.2 *Virtual Team Definitions*

Early definitions of virtual teams sought to contrast virtual teams and face-to-face teams, and therefore focused on physical dispersion and technology-based interaction. An examination of the definitions used indicates a considerable overlap in the core definition of virtual teams, with some small variation in the specifics. Under this original

framework, virtual teams were broadly defined as teams of collaborative individuals, who worked together over time, space, and distances using information technology (such as email or audio/video conferencing) to achieve a common goal (Duarte & Snyder, 1999; Fiol & O'Connor, 2005; Hertel et al., 2005; Martins et al.; Maznevski & Chudoba, 2000). Although these initial definitions were appropriate for the context in which they were originally used, namely laboratory settings using student participants. More recently however, the focus of inquiry has shifted towards organizational teams working on "real-world" tasks. With this shift the definition of virtual teams has begun to undergo some transformation and refinement (Martins et al., 2004; Fiol & O'Connor, 2005).

The growing trend among researchers is a belief that virtual teams cannot simply be integrated into existing typologies of teams and must instead represent an entirely new type of team. Two schools of thought have since developed. The first is that virtual teams should be defined by the "extent of virtualness." Under this framework teams are defined based on the extent that a team relies on virtual tools to work and communicate. Thus, a team's virtualness depends on the nature of the team's tasks, technological resources, and team member skills and capabilities (Griffith, Sawyer, & Neale, 2003; Fiol & O'Connor, 2005; Kirkman & Mathieu, 2005; Martins et al., 2004). The second school of thought is that virtual teams should not be defined based on a continuum, but instead be defined based upon how well a team falls into one of three distinct team categories. These categories include traditional teams, hybrid teams, and teams that are purely virtual. Traditional teams are teams that do all of their work in face-to-face settings and make no use of technological support. Purely virtual teams are teams that never meet face-to-face and who interact solely through the use of information technologies. Lastly, hybrid teams are teams composed of members who interact over time, space, and distances according to the needs of the moment, and through the use of communication media, with the amount of face-to-face contact determined by the requirements of the task and the resources available (DeSanctis & Poole, 1994; Fiol & O'Connor, 2005; Griffith et al., 2003).

Additional virtual team elements are discussed in the literature, but are not widely accepted. One such element is that virtual teams are often conceptualized as having a fluid membership, such that a specific expertise can be added to or removed from the team as tasks change (Kirkman et al., 2004; Martins et al., 2004). Virtual teams have also been described as having the tendency to possess shorter lifecycles compared to face-to-face teams (Jarvenpaa & Leidner, 1999; Martins, Gilson, & Maynard, 2004).

Researchers have also looked into what kind of work teams a virtual team can be made up of. Table 9 lists all of the different kinds of virtual work teams discussed in the literature.

Table 9

Types of Virtual teams mentioned in the literature

Types of Virtual Teams	Hertel et al. (2005)	Duarte & Snyder (1999)	Kayworth & Leidner (2000)	Montoya, Masssey, Hung, & Crisp, (2009)	Cordery et al. (2009)	Cascio & Shurygailo (2003)
Networked teams		X				
Parallel teams		X			X	
Project or product-development teams		X		X		
Work or production teams		X				
Service teams		X				
Management teams		X				
Action teams		X				
Global teams			X		X	
Teleworkers	X					X

2.2 Technology

The communication and coordination activities of virtual team members are facilitated by technology. Technology can be characterized along three continua: time, space, and level of group support (Warkentin, Sayeed, & Hightower, 1997; Townsend et al., 1998). Teams are able to communicate synchronously or asynchronously; they may be located together or remotely; and the technology provides task support for an individual team member or for the entire group's activities (Guo et al., 2009; Kiesler & Sproull, 1992; Townsend et al., 1998; Warkentin et al., 1997). Further, computer-mediated communication systems increase the range, capacity, and speed of managerial communications (Warkentin et al., 1997). These computer-mediated communication systems can also reduce or eliminate the expense and inconvenience associated with distributed work (Hertel et al., 2005; Sproull & Kiesler, 1986; Warkentin et al., 1997).

Computer-mediated communication technologies can provide support for synchronous or asynchronous communication. Synchronous communication technologies allow for the ability to spontaneously communicate (Warkentin et al., 1997; Guo et al., 2009). It is estimated that managers spend 60% of communication time in synchronous meetings, which include face-to-face meetings, telephone calls, desktop conferencing, and web-based "chat rooms" (Warkentin et al., 1997). On the other hand, asynchronous communication technologies offer more structured means of communication. Asynchronous communication relies more on documents exchanged among participants. Compared to synchronous communication, asynchronous communication gives participants more time to compose messages. Asynchronous work requires more time than synchronous meetings because information exchange takes longer (Warkentin et al., 1997). Table 10 lists ten of the most commonly used computer-mediated communication technologies as found in the literature (Griffith et al., 2003; DeSanctis & Poole, 1994; Martins et al., 2004; Warkentin et al., 1997).

Table 10

Commonly used computer-mediated communication technologies

Telephones
Email
Websites
Instant messaging
Video/audio conferencing
Electronic document management systems
File and application sharing systems
Electronic bulletin boards
Group decision support systems
Real-time calendar/scheduling systems

2.2.1 *Technology Selection and Usage*

Computer-mediated communication technologies have changed how people can meet and how they make decisions in groups. People can "talk" as a group outside of the meeting room, at once or asynchronously, whether the group has 2, 200, or 2000 members, whether they work in the same building or across the world. Not just the physical aspects of meetings have changed with technology, but the dynamics of group decision making have also been shown to differ between virtual teams and face-to-face teams (Kiesler & Sproull, 1992).

A review of the literature reveals that throughout the years many strategies have been developed for selecting computer-mediated communication technologies for a virtual team to use, along with how to best leverage the technologies a virtual team has access to. Media richness theory and social presence theory were the most widely accepted approaches of early researchers (Montoya et al., 2009; Guo et al., 2009). Early researchers initially described computer-mediated communication technologies in terms of the objective characteristics of the technology's medium. Media richness theory

(sometimes referred to as information richness theory) categorizes different computer-mediated communication technologies according to the availability of immediate feedback, personalization, and language variety. It suggests that when messages are simple, a lean or basic medium, such as email, should be used. When messages are complex, a richer medium, such as video conferencing, should be used (Daft & Lengel, 1984; Zigurs, 2003; Walther J. B., 1995; Montoya et al., 2009; Wiesenfeld et al., 1999; Ngwenyama & Lee, 1997; Zigurs & Buckland, 1998; Kirkman & Mathieu, 2005). Social presence theory classifies different computer-mediated communication technologies along a one-dimensional continuum of social presence, where the degree of social presence is equated by the degree of awareness of the other person(s) involved in an interaction. According to social presence theory, communication is effective when the computer-mediated communication technology used transmits a social presence equivalent to the level of interpersonal involvement required by the task (Montoya et al., 2009; Carlson & Zmud, 1999; Walther J. , 1992; Wiesenfeld et al., 1999; Walther J. B., 1995).

In contrast to these earlier theories which focus solely on the technology, more recent theories have begun to include social dynamic perspectives (Montoya et al,, 2009; Carlson & Zmud, 1999; Walther J. , 1992; Wiesenfeld et al., 1999). These theories include: structuration theory, social influence theory, social information processing theory, the time, interaction, and performance theory, media synchronicity theory, and channel expansion theory. These theories, all consistent with one another, emphasize both the social and dynamic aspects of communication.

Structuration theory suggests that as social structures evolve, a team's communication and technologies use will "shape" each other. For example if a team relies heavily on email to communicate, often team members resort to using emoticons (i.e. smiley faces :-), frown faces :-(, and etc) to overcome email's inability to transmit some of the social cues found in face-to-face communication (Montoya et al., 2009; DeSanctis & Poole, 1994). Social influence theory attempts to identify social psychological processes that can

be used to explain patterns of meanings and behaviors related to technology use. An example might be how a favorite communication medium of a respected colleague, like telephone calls or video conferencing, may influence how another person chooses the technologies they will use (Montoya et al., 2009). Social information processing theory suggests that online, interpersonal relationship development requires more time than traditional face-to-face relationships. However once established, online personal relationships demonstrate the same relational dimensions and qualities as face-to-face relationships (Montoya et al., 2009; Walther J. , 1992; Warkentin & Beranek, 1999; Walther J. B., 1995). Time, interaction and performance theory emphasizes the temporal processes in team interaction and argues that teams and the computer-mediated communication technologies that support them cannot be disentangled from their surrounding social and organizational systems (Montoya et al., 2009). Media synchronicity theory suggests that richness of a communication medium may be relative, depending on how well a person knows their teammates, the context of a communication, the topic, and etc. Meaning that the richness of a communication channel may expand not because of the characteristics of the medium itself, but instead because of the context in which the technology is used (Zigurs, 2003). Lastly, channel expansion theory suggests that the perceptions of the computer-mediated communication technologies a team uses will evolve as users gain experience with messaging topics, their individual team members, and the technologies that the team uses (Montoya et al., 2009; Carlson & Zmud, 1999).

2.2.2 *Transactive Memory Systems*

Recent studies suggest that knowledge coordination in virtual teams is problematic due to temporal and spatial separation among team members (Kanawattanachai & Yoo, 2007; Cramton, 2001; Hertel et al., 2005; Alavi & Tiwana, 2002). In virtual teams, team members do not share a common physical environment in which cues of others' state of work is provided. As a result, participants do not have a common orientation and/or reference points for progress or status (Leinonen et al., 2005). Furthermore, virtual teams

are often short-lived and consist of members who are not familiar with one another. Kanawattanachai and Yoo (2007) state that "the problem of mutual knowledge is a central issue in understanding how virtual teams perform and develop."

There is no consensus among researchers on the most significant contributing factors that cause problems to mutual knowledge development; however, trends in research suggest a virtual team's ability to develop transactive memory systems may be one of the more fruitful means for overcoming knowledge management issues. Transactive memory-systems are information systems like online blackboards that allow teams to post individual background and skills inventory information. These systems also provide teams the ability to track their progress toward goals or objectives (Rosen, Furst, & Blackburn, 2007). Such systems also provide team member access to discussion boards, phone lists, and links to common documents (Kanawattanachai & Yoo, 2007; Malhotra, Majchrzak, & Rosen, 2007; Mohammed & Dumville, 2001; Wegner, 1986; Griffith et al., 2003). In these technically-constructed workspaces, it is possible to consider 'who', 'what', 'where', 'when' and 'how' interactions took place. This kind of 'on-line' knowledge about team member interactions can contribute to the effectiveness by which work gets done and provide team members with an understanding of who is in the workspace, where they are working, and what they are doing (Leinonen et al., 2005; Alavi & Tiwana, 2002; Wegner, 1986)

Past research on transactive memory systems has been primarily conducted in face-to-face environments. This previous research has shown that traditional face-to-face teams with effective transactive memory systems perform better than teams without transactive memory systems (Griffith et al., 2003; Hertel et al., 2005). Some prior studies have also suggested that transactive memory systems are important in virtual environments (Griffith et al., 2003; Leinonen et al., 2005). Leinon et al. (2005), for example, was able to show that if a transactive memory system is embedded in a shared virtual workspace, it can deepen individual team member awareness of collaboration and also help teams develop shared mental models.

2.3 Trust Development

The development of trust presents significant challenges to a virtual team. The environment where virtual teams interact is filled with uncertainty. Questions typical to virtual teams include, are other individuals reading the messages I'm sending? and if not, why not? Are they having technical problems, or are they just not committed? Such uncertainties work against the development of trust and can significantly challenge the viability and effectiveness of a virtual team. Moreover, the life of many virtual teams is relatively limited, and trust must develop quickly (Jarvenpaa & Leidner, 1999; Powell et al., 2004).

The development of trust within a virtual team is critical to a team's ability to be successful (Peters & Karren, 2009; Jarvenpaa et al., 1998; Coppola et al., 2004; Robert, Dennis, & Hung, 2009; Dirks & Ferrini, 2001; Jarvenpaa & Leidner, 1999). Some researchers have stated that a virtual team cannot develop trust without the use of face-to-face meetings (Jarvenpaa et al., 1998; Dirks, 1999). More recent studies however, have shown that high levels of trust can develop in a virtual team through the development of "swift trust" (Jarvenpaa & Leidner, 1999; Coppola et al., 2004; Peters & Karren, 2009). Whereas traditional conceptualizations of trust are based strongly on interpersonal relationships, swift trust deemphasizes the interpersonal dimensions of trust. It states that trust can develop initially as a result of broad categorical social structures, and later based on team member actions (Jarvenpaa & Leidner, 1999; Powell et al., 2004; Peters & Karren, 2009; Coppola et al., 2004; Meyerson, Weick, & Kramer, 1996).

Meyerson et al. (1996) developed the concept of swift trust. Swift trust was originally developed for temporary teams whose existence, like those of virtual teams, is formed around a common task with a finite life span. Such teams consist of members with diverse skills, a limited history of working together, and little prospect of working together again in the future. The tight deadlines under which these teams work leaves little time for relationship building. Time pressures hinder the ability of virtual team members to develop expectations of their teammates based on firsthand information.

Instead team members must import expectations of trust from other settings with which they are familiar (Jarvenpaa & Leidner, 1999; Powell et al., 2004; Peters & Karren, 2009; Coppola et al., 2004). With swift trust individuals make initial use of category-driven information processing to form stereotypical impressions of others. After the team has begun to interact, trust is maintained by a "highly active, proactive, enthusiastic, and generative style of action" (Meyerson et al., 1996). Action strengthens trust in a self-fulfilling fashion: action will maintain members' confidence that the team is able to manage uncertainty, risk, and vulnerability (Jarvenpaa & Leidner, 1999; Powell et al., 2004).

Recently researchers have begun to explore the possibility that the development of trust may be a dynamic process (Hertel et al., 2004; Peters & Karren, 2009; Robert et al., 2009). Robert, Dennis, & Hung (2009) have shown, for example, that knowledge-based trust and swift trust are not independent contradictory views of trust formation, but instead are two separate processes by which trust is formed at different stages of a relationship. After team members accumulate enough information about one another's trustworthiness, the effects of swift trust decline and knowledge-based trust, based on perceived ability, integrity, and benevolence become dominant. However, the impact of the initial swift judgments, which can often be inaccurate, have been shown to linger and influence knowledge-based trust judgments (Robert et al., 2009).

Researchers have also approached the development of trust through varying lenses. Piccoli and Ives (2003), for example, analyzed trust development based on the amount of reneging (when people recognize that they have an obligation and knowingly fail to meet it), and incongruences (when people unknowingly fail to follow through on an obligation). Galivan (2001) looked into the effects of using controlling mechanisms as opposed to trust building to establish high levels or performance in virtual teams, and Dirks and Ferrini (2001) and Jarvenpaa et al. (2004) looked into how trust could be used as a managerial tool.

2.4 Virtual Team Leadership/Management

In this section, literature addressing general leadership recommendations, critical factors, and leadership styles isdiscussed.

2.4.1 *General Recommendations for Virtual Team Leaders*

The management and leadership of a virtual team is frequently cited as the most influential factor in a virtual team's ability to be successful. One of the most frequently cited recommendations is a need for communication standards (Cordery et al., 2009; Duarte & Snyder, 1999; Kayworth & Leidner, 2002; Solomon, 1995; Zigurs, 2003). Also noteworthy is a need to create clear and understood shared goals and expectations of how team members will be evaluated within the team and a strong task orientation within the team, (Cordery et al., 2009; Duarte & Snyder, 1999; Kayworth & Leidner, 2002; Malhotra et al., 2007; Solomon, 1995; Townsend et al., 1998; Zigurs, 2003). The leadership recommendations and sources in the literature are summarized in Table 11.

Table 11

Recommendations for leaders of virtual teams

	Cordery et al. (2009)	Duarte & Snyder (1999)	Kayworth & Leidner (2002)	Malhotra et al. (2007)	Solomon (1995)	Townsend et al. (1998)	Zigurs (2003)
Establish standards for communication	X	X	X	X	X		X
Build and sustain team member relationships	X	X	X	X			X
Create common, shared goals	X	X	X		X	X	
Ensure individuals benefit from the virtual team experience			X	X			
Clearly establish expectations	X	X	X			X	X
Create and communicate a clear vision	X		X				X
Continually emphasize the team's purpose and its measurable outcomes		X		X	X		
Create a strong task orientation	X	X	X	X	X		
Create a supportive environment		X	X	X			X
Build team engagement	X	X		X			X
The team leader needs to project a level of telepresence							X

2.4.2 *Critical factors*

In addition to the general recommendations described in 2.4.1, there are also factors that researchers describe as critical to a virtual team's ability to be effective. Trust is one such factor, trust can be hard to develop in a virtual team, because of this team leaders need to apply extra care in ensuring that the team is able to develop a high level of trust and maintain that trust throughout the life of the virtual team (Hertel et al., 2005; Jarvenpaa & Leidner, 1999). The recommendations are for team leaders to facilitate the development of swift trust within a team as described in 2.3.

Technology is another critical factor that virtual team leaders need to give attention to. Technology issues stem from the heavy reliance virtual teams must place on the

technology they use (Kayworth & Leidner, 2002). The recommendations for technology selection and use, not discussed previously, are for the teams to utilize multiple computer-mediated communications systems. Team members should be trained in the use of the technologies that the will team use. The team leader should also ensure that the technologies the team will use is be compatible with the resources available at each individual location were team members will be working (Montoya et al., 2009; Kayworth & Leidner, 2000; Kayworth & Leidner, 2002).

The development and maintenance of a team's structure and ground rules is another critical factor that a virtual team leader needs to attend to. Ground rules and structure offer a virtual team a common understanding, and allow the team to cope with the limitations that are inherently part of the technology that virtual teams must use. Team leaders need to establish conduct rules clarifying how the team should interact when team members have dissenting views, participation expectations at meetings should be outlined, and rules for communication, such as what turnaround time should be expected on emails or missed phone calls. There should also be rules that clarify the duration and frequency with which the virtual team will have meetings, along with any other rules that a team or team leader feel would be helpful to the functioning of team.

Since different communication media differ in their ability to convey "social presence," team communication is another factor team leaders need to give special attention to (Kayworth & Leidner, 2002). To ensure team members do not misinterpret different forms of communication, team leaders should emphasize communication that facilitates continuous communication patterns within the team. Also, due to the likelihood that important social/contextual information, such as member's social status or level of expertise, may be lost or distorted in virtual team environments, team leaders need to ensure individual roles are clearly understood by all team members (Kayworth & Leidner, 2002).

The management of virtual team meetings is another influential factor affecting a virtual team's ability to be effective (Malhotra et al., 2007). Meetings need to be preplanned with set schedules and have rules of engagement. If at all possible face-to-face meetings should be held in the early stages of the virtual team and continued throughout the life of the virtual team (Kayworth & Leidner, 2000; Kayworth & Leidner, 2002; Solomon, 1995).

Team diversity, also, is a factor that can prove critical to a virtual team's ability to be effective. Diversity among team members can lead to coordination difficulties and create obstacles to effective communication (Kayworth 2000). To ensure that this does not happen, special attention should be paid to the level of diversity within a virtual team. The diversity in the team needs to be understood, embraced, and leveraged (Malhotra, Majchrzak et al., 2007). To achieve this, team leaders should instill a sense of cultural awareness within the team, and efforts should be made to understand and accept individual differences. The team leader should also develop and share an expertise directory and skills matrix with all virtual team members (Malhotra et al., 2007; Kayworth & Leidner, 2000; Powell et al., 2004; Sarker & Sahay, 2003).

A summary of all the factors described as critical to a virtual team or factors explicitly researched is provided in Table 12. Appendix B is expanded to include relevant references each factor listed in Table 12.

Table 12

Factors described as critical or explicitly researched in the literature

Behavior Control	Shared Mental Models
Collaboration	Task Interdependence
Collaboration Awareness	Task and Team Familiarity
Common Incentives and Goals	Team Based Rewards
Communication	Team Cohesion
Communication Standards	Team Conflict
Conflict Resolution	Team Design
Coordination	Team Empowerment
Culture	Team Flexibility
Evaluations and Rewards	Team Identification
Feelings of Isolation	Team Knowledge, Skills, and Abilities
Group Composition	Team Meetings
Human Resource Policies	Team Member Silence
Leader Delegation	Team Planning
Leadership Support	Team Size
Motivation	Team Structure and Norms
Mutual Knowledge	Technology
Personality Traits of Team Members	Training
Relational Development	Transactive Memory
Reward Systems	Trust Development
Role Clarity	

2.4.3 *Effective Leadership Styles*

Of all of the material on leadership in virtual teams there is only a limited amount of literature that directly addresses leadership styles and approaches. Of the literature reviewed, only three articles directly addressed appropriate leadership styles, i.e. Kayworth & Leidner (2002), Purvanova & Joyce (2009), and Hertel et al. (2005).

Kayworth and Leidner (2002) describe three different leadership perspectives. The first perspective is called the contingency perspective of leadership. Under this approach effective leadership is said to depend on situational factors related to the task at hand, the individuals involved, and with the technology being used. The second leadership perspective is called the behavioral complexity theory of leadership. Under this theory, effective leaders are able to optimize both relational and task-related orientations. The third leadership perspective is behavioral complexity theory. Under this theory, effective leadership is dependent upon the leader's ability to display multiple, contrasting leadership styles in complex settings. Of the three theories, the behavioral perspective of leadership was shown to be the most potent strategy of the three. However, the behavioral complexity model was demonstrated by all of the effective leaders in the study. It was suggested that a behavioral perspective of leadership and behavioral complexity theory are consistent and supportive of each other. Support for the contingency perspective was not definitive. Kayworth and Leidner (2002) did not collect data on this leadership style, and therefore no relationships were substantiated. However, it was apparent from Kayworth and Leidner (2002)'s analysis that the contingency perspective placed an added emphasis on leader communication and relational skills, which with further research could be shown to be a fruitful leadership style.

Purnova and Joyce (2009) discussed the impact of using a transformational leadership style. Transformational leadership is a leadership approach that creates valuable and positive change in team members. A transformational leader focuses on "transforming" others to help each other, to look out for each other, to be encouraging and harmonious, and to look out for the organization as a whole. In this leadership style the leader enhances motivation, morale, and performance of the group. Purnova and Joyce's (2009) findings suggested that transformational leadership behaviors were instrumental to team performance in virtual teams. No data was gathered to justify why transformational leadership was an effective technique in virtual teams, however three possibilities were suggested. The first reason described, is that virtual team members may feel less known when interacting with other team members in the impersonal environment created by the

virtual media. Through the development of high quality relationships with their virtual team members, a transformational leader can increase followers' sense of being known, and thus helping them feel appreciated and important. Transformational leaders may also help team members identify with the team's tasks and goals by developing a common mission, team cohesion and team identity. Lastly it was suggested that virtual team members can easily be confused and overwhelmed by the less natural computer-mediated communication environments. Because transformational leaders are able to introduce a sense of purpose and certainty within the team, by setting specific goals and developing agendas for goal achievement, such leaders are able to help the team overcome these challenges.

Hertel et al. (2005) described three different leadership approaches to use depending on the degree of team member autonomy. These approaches are electronic performance monitoring, management by objectives, and self-managed teams. Electronic monitoring attempts to create directive leadership over distance. Using network technology, electronic performance monitoring systems allow managers to monitor their employees' working pace, degree of accuracy, log-in and log-off times, and customer orientation at any given moment, and enable some direct performance control mechanisms similar to conventional work settings. Electronic performance monitoring emphasizes standardization and simplification of work processes. Most of the studies exploring the effects of electronic performance monitoring have been conducted with individual workers rather than with teams. The few studies that have investigated the effects of electronic performance monitoring at the team level revealed that it is difficult to employ electronic performance monitoring without negative effects on employees, such as increased stress levels and decreased job satisfaction. Thus, the efficacy of electronic performance monitoring for virtual teams is low.

Management by objectives is a set of management practices that place emphasis on goal setting, participation, and feedback related to task fulfillment. Hertel et al. (2004) conducted a field study to explore the effects of management by objectives in virtual

teams. The study results indicated that a significant correlation between goal quality, as perceived by the team members, and the effectiveness of the teams, as measured by the team manager, existed. The study also showed that performance related feedback should be frequent, concrete, and timely at both the individual and group level. Feedback about social processes might be another important factor in virtual teams because it can help to bridge spatial disconnectedness and increase cohesion and trust (Hertel et al., 2005).

While delegative management approaches still rely on a formal team leader, it is also conceivable that virtual teams might be completely self-managing. Although some examples of highly self-organized, virtual collaboration exist, researchers agree that most virtual teams need guidance and managerial support beyond the mere provision of an electronic groupware system, e.g. Duarte & Snyder (1999), Hertel et al. (2005), Jarvenpaa & Leidner (1999), and Lipnack & Stamps (1997).

2.5 Research Model Variables

In this section, literature addressing the effects of shared ownership, shared mental models, and resource utilization on team performance and member satisfaction is discussed.

2.5.1 *Shared Ownership*

The effort to find literature that included direct references to the concept of shared ownership was unsuccessful. The terms ‘shared ownership,’ ‘shared responsibility,’ and ‘shared evaluations’ were used in the search. The literature search was conducted using academic databases, the world wide web, Oregon State University library’s general catalog; and multiple books on organizational psychology. The author developed a working definition for shared ownership based on related concepts in the team literature, including the literature on shared mental models. The details of the operationalization of shared ownership are discussed in more detail in chapter 3.

2.5.2 *Shared Mental Models*

A plethora of cognitive terminology has been developed to help explain the process by which individuals make sense of their surroundings, some examples include: categories, cognitive maps, belief structures, mental models, schemas, and scripts (Klimoski & Mohammed, 1994). Of the cognitive terminology mentioned, the concept of mental models is widely accepted among researchers and will be the focus of this section.

While the phrase "mental models" is ubiquitous in the literature, there are surprisingly few researchers who clearly define or even explicitly describe what is meant by the term. Most authors do not go beyond describing a collectivity of beliefs, shared understanding, or some similarity in the way information is processed (Klimoski & Mohammed, 1994; Rouse, Cannon-Bowers, & Eduardo, 1992). Rouse et al. (1992, pg 1300), however, developed the following definition: "Mental models are mechanisms whereby humans are able to generate descriptions of system purpose and form, explanations of system functioning and observed system states, and predictions (or expectations) of future system states."

The term "shared" in shared mental models refers to a cognitive representation that is identical among team members (e.g. common knowledge), a distributed configuration of representations (with no overlap), and/or a configuration of overlapping representations among group members. Shared mental models can be and usually are found in the form of multiple mental models co-existing among team members at any given point in time (Klimoski & Mohammed, 1994).

Mental models come in four forms: an equipment model, a task model, a team interaction model, and a team model. The equipment model captures team members' shared understanding of the technology and equipment with which they carry out team tasks. The task model captures team member perceptions and understanding of team procedures, strategies, task contingencies, and environmental conditions. The team interaction model reflects team member understanding of responsibilities, norms, and

interaction patterns. Lastly, the team model summarizes team member understanding of the knowledge, skills, attitudes, strengths, and weaknesses of the team (Lim & Klein, 2006).

An assessment of shared mental models is frequently conducted in terms of accuracy and similarity (Edwards, Day, Aruthur, & Bell, 2006; Lim & Klein, 2006; Xie, Zhu, & Wang, 2009). The accuracy of a shared mental model is how well mental models, shared by the team members, accurately represent the system that they are trying to describe. The similarity of shared mental models is how well team members share the same mental models (Lim & Klein, 2006). Both the accuracy and similarity of shared mental models have been found to be strongly related to each other, but not redundantly so (Edwards et al., 2006; Lim & Klein, 2006). Accurate mental models have been shown to affect performance. Although this finding is widely accepted in the literature, not all research studies have been able to substantiate this finding (Lim & Klein, 2006). In addition, although high levels of similarity between team member mental models have been shown to affect performance, mental models high in similarity but lacking in accuracy, have been shown to lead to the development of "group think." Group think occurs when individuals in a group try to minimize conflict and reach a consensus without critically testing, or analyzing the decisions being made or discussed (Edwards et al., 2006; Lim & Klein, 2006).

Mental models serve three purposes for a team, mental models help with description, explanation and prediction. Description involves team knowledge of what a system is for and what the systems looks like. Explanation is the team's understanding of how the system works and interpretation of what the system is currently doing. Lastly prediction is the team's expectations about what the system is likely to do (Rouse et al., 1992).

Of the seven studies reviewed on shared mental models, only one study critically evaluated a method for developing shared mental models. This method involved the use of planning activities to stimulate the development of shared mental models. Stout et al.

(1999) found that when members of teams engaged in high-quality planning, were able to form a better shared mental model of each team member's informational requirements. Also, noted in the literature, but not thoroughly discussed, was the use of training to develop shared mental models (Edwards et al., 2006; Rouse et al., 1992).

One of the major emphases in the literature is the ability of shared mental models to affect team performance. A direct link between the development of shared mental models and team performance has yet to be well-documented in the literature (Klimoski & Mohammed, 1994). There is, however, a widely accepted belief, among researchers and practitioners alike, that the development of shared mental models has a direct and positive effect on team performance (Edwards et al., 2006; Klimoski & Mohammed, 1994; Lim & Klein, 2006; Peterson, Mitchell, Thompson, & Burr, 2000; Rouse et al., 1992; Stout et al., 1999; Xie et al., 2009).

2.5.3 *Resource Utilization*

The operationalized definition of resource utilization is the extent to which a team effectively utilizes key resources including team member knowledge. Upon an initial search for literature on resource utilization, no literature directly related to resource utilization was identified. An alternate search strategy was used. Instead of searching for literature using the term, 'resource utilization,' 'knowledge management,' 'knowledge coordination,' and 'knowledge sharing/transfer' were used as alternate key words in conducting the literature search.

Knowledge is essential to resource utilization. For a team to effectively utilize team resources, team members need to be aware of available resources and have the knowledge and capacity to make use of those resources. To achieve this, teams must manage, coordinate, and share knowledge within the team (Cook & Brown, 1999).

Although not universally accepted, there is a general consensus among researchers that there are four categories of knowledge: explicit, tacit, individual and group (Cook & Brown, 1999). A visual representation of the four forms of knowledge and examples of the type of knowledge that can be created when any two forms of knowledge coexist is shown in Figure 2.

	Individual	**Group**
Explicit	Concepts	Stories
Tacit	Skills	Genres

Figure 2: The four types of knowledge and examples of the type of knowledge that can be created when any two forms of knowledge coexist

Table 13 summarizes research questions being posed in the literature related to both individual and group level knowledge and both explicit and tacit knowledge.

Table 13

Example research questions from the literature which consider explicit, tacit, individual, and group forms of knowledge

Questions posed in the literature	Sims & Gioia (1986)	Simon (1991)	Sitkin (1992)	Cohen & Bacdayan (1994)	Nonaka (1994)	Weick & Westley (1996)	Weick (1991)
How explicit knowledge acquired by individuals in an organization is associated with "learning" at the level of the organization"	X	X	X				
How a group's mastering of explicit routines can be an aspect of organizational memory				X			
How the tacit skills of an individual can and cannot be tapped for the benefit of the organization					X		
How the activities of groups can constitute organizational learning						X	X

There is a tendency among some researchers to treat differing forms of knowledge as essentially the same. That is, the epistemology assumed in some of the literature tends to emphasize the individual over the group and the explicit over the tacit (as if, for example, explicit and tacit knowledge were two variations of one kind of knowledge). Table 14 presents examples of how some researchers describe knowledge as being made up of two categories (i.e. explicit/tacit knowledge and individual/group knowledge).

Other researchers posit that treating knowledge as having only two forms or dimensions (i.e. explicit/tacit and individual/group) severely limits a team's or organization's ability to leverage the knowledge stored within a team/organization (Cook & Brown, 1999; Cramton, 2001). A demonstration of how knowledge is made up of four distinct categories and not just two continuums of knowledge can be shown through two examples. The knowledge required to be able to ride a bicycle provides a good example of the distinction between explicit and tacit knowledge

Table 14

Examples of how some researchers confine knowledge to two categories: explicit/tacit and individual/group

Examples from Literature	Source
"All learning takes place inside individual human heads . . . "	(Simon, 1991, p. 125)
"While tacit knowledge held by individuals may lie at the heart of the knowledge creating process, realizing the practical benefits of that knowledge centers on its process of 'converting' tacit knowledge into explicit knowledge"	(Nonaka, 1994, p. 20)
"Individuals store components of a routine as a procedural memory"	(Cohen & Bacdayan, 1994, p. 554)
Weick and Roberts (1993) describe the "collective mind" in terms of "a distinct higher-order pattern of interrelated activities" grounded in and emerging from "individual actions"	(Weick & Roberts, 1993, p. 374)
Hutchins (1991) speaks of investigating the "ways in which the cognitive properties of human groups may depend on the social organization of individual cognitive capabilities."	(Hutchins, 1991, p. 284)

To have the capability to ride a bicycle one needs to have the (tacit) knowledge that allows a person the ability stay upright when riding. This knowledge is not an explicit understanding of the activity itself, but is instead knowledge used in the act of riding. No amount of explicit knowledge alone can enable someone to be able to ride a bicycle. One must first acquire the required tacit knowledge, such as balance and muscle memory, before that person will have the capability to ride a bicycle. It is even foreseeable for someone to have studied the requirements of riding a bicycle in great detail and be very knowledgeable in the technical details of how to ride a bicycle (i.e. the explicit knowledge), but yet still not be able to ride one. (Cook & Brown, 1999).

Individual and group knowledge can be described in terms of what is known about a given domain. Individuals possess various bits of knowledge of a field, but the "body of knowledge" for a particular field is possessed by groups, not by individuals. Put another way, the body of knowledge of a group is "held in common" by the group. Every individual is not expected to know everything in the "body of knowledge" (in fact, this is likely to be impossible). An example that distinguishes groups and individual knowledge can be drawn from the field of nephrology. Nephrology is a branch of medicine that specializes in the diseases of the kidneys. The knowledge required to diagnose nephritis (i.e. inflammation of the kidney) using palpation can only be possessed by the individual physicians (i.e. groups do not have hands), however the knowledge of what constitutes acceptable and unacceptable practice in nephrology is possessed by the nephrologists as a group (Cook & Brown, 1999).

Barriers to the generation and sharing of knowledge have also been identified in the literature. Table 15 lists some of the common barriers identified in previous research. In addition to barriers to knowledge sharing/transfer, recommendations for best practices were discussed. The five general recommendations for knowledge transfer, specific to virtual teams are first to gather information about differing locations of team members. Second, integrate the knowledge within the team, and regularly update that information. Explanations for unexpected behavior and silences must be investigated. Exchanges

between subgroups should be reported to the whole group. Finally, feedback lags, which may be different for each location, must be taken into account (Cramton, 2001).

Table 15

Barriers to the generation and sharing of knowledge

Barrier	Szulanski (1996)	Crampton (2001)	Leonard & Sensiper (1998)
An inability of the recipient of the knowledge transfer/sharing to leverage and use the new knowledge	X		
A source is perceived as unreliable	X		
Arduous relationships (i.e. difficulties facing the transfer of knowledge, coupled by the social relationships shared by the involved parties)	X		
Communication technology (specific to virtual teams)		X	
Difficulty communicating the salience of information		X	
Difficulty understanding the salience of information		X	
Distance between team members (i.e. both physical separation and time zone differences)		X	X
Fear that the result of sharing an idea will be emotional disagreement (as opposed to an intellectual disagreement)			X
Group communication preferences that oppose individual team member preferences or styles			X
Lack of creditability			
Lack of motivation	X		
Status differences between team members			X
When two or more team members have conflicting information, and are unaware to the fact		X	

Recommendations were not only made at a team level but were also made for individuals who want to be perceived as effective knowledge transfer agents. To be an effective

knowledge transfer agent it is suggested that a person needs to fully participate in electronic conversations, as measured by the team's communication volume. The individual also needs to be perceived as credible as a result of exhibiting trustworthy behaviors and high performance, and through the demonstration of collectivist values (Sarker, Sarker, Nicholson, & Joshi, 2005).

Two previous studies (Cummings, 2004; Kanawattanachai & Yoo, 2007) have looked at the relationship between knowledge sharing and team performance. In both studies successful teams took advantage of the perspectives, talents, and ideas of the different members within their teams. Further, research has shown that the volume and frequency of task-oriented communication is a significant determinant of team performance in the initial phase of the project.

Based on this review of the literature, multiple opportunities for research on virtual teams were identified. In particular, this review confirmed that there is a need for research to provide a deeper understanding of the role of shared ownership and team processes on the performance of virtual teams.

3 Methodology

There is recognition of the benefits of combining quantitative and qualitative methods in research (Bamberger, 2000). In this study both quantitative and qualitative methods were used. The quantitative methods were adopted to quantify the existence of each dependent variable and allow for testing of each hypothesis. The qualitative analysis was used to provide an additional lens with which to evaluate the results obtained from the quantitative analysis. The quantitative and qualitative methodologies are discussed in general terms next. This is followed by a detailed overview of the data collection and analysis of both the 2008 and 2009 studies.

3.1 Quantitative Methods

The quantitative data collected in both the 2008 and 2009 study were gathered through the administration of two surveys. One survey was administered in the 2008 study and one in the 2009 study. Both surveys were administered after the virtual teams had completed their projects. In each study, constructs were developed to measure the existence of each of the dependent variables. In the quantitative analysis each construct was composed of survey items that when evaluated together provided a measure of each dependent variable. In the 2008 study each construct contained between two and five survey items. Each construct in the 2009 study contained four survey items. Each survey item was measured using a six-point Likert scale for the 2008 survey and a five-point Likert scale for the 2009 study.

To assess the quality of the survey, both the reliability and validity of each survey construct were evaluated. Survey reliability can be defined as the consistency or stability of the survey items in a single construct, and survey validity can be defined as a measure of how accurately and precisely survey items reflect each construct, and thus the dependent variables (Muchinsky, 1997). Survey reliability was calculated by determining the internal consistency of each construct. Internal consistency measures the extent to which each survey construct contains homogenous data (Muchinsky, 1997). The internal

consistency of each construct was determined using Cronbach's alpha. Cronbach's alpha is a widely recognized method of evaluating the internal consistency of a survey construct (Muchinsky, 1997; Hayes, 1992).

The validity of the survey was measured in terms of content validity. Content validity is the degree to which each construct measures a representative sample of the variable being assessed. Content validity is assessed by subject matter experts in the area that the survey covers (Muchinsky, 1997). In this research the subject matter experts who evaluated the validity of constructs were the author of this text and his academic advisor.

To test the hypotheses developed for this research, a path analysis was proposed. Path analysis is a research tool often used in the social sciences. It is a useful method for testing relationships between multiple real-life variables (Li, 1975). Path analysis (a special case of structural equation modeling) is a method for providing direct and indirect estimates of the magnitude and significance of hypothesized causal relationships between sets of variables (Webley & Lea, 1997). Path diagrams are used to graphically display the different variables and the proposed direction of causality between them. Path coefficients, which are standardized multiple regression coefficients (beta weights), are calculated to quantify the strength of the relationship between each pair of variables (Li, 1975).

It is important to note that path analysis is not intended to deduce causal relations: it is useful in testing theory rather than in generating it. In addition, some assumptions underlie the application of path analysis. The assumptions are relationships are linear, additive, and causal, and variables are measurable on an interval scale. Another assumption is that residuals are not correlated among themselves or with the system variables; this implies that all relevant variables are included in the system (Kerlinger & Pedhazur, 1973).

To test the hypotheses, regression and nonparametric tests of central tendency were identified as the most appropriate statistical tools for the analysis. In the 2008 study, to evaluate the effects of shared mental models and resource utilization on team performance and team member satisfaction, ordinary least squares (OLS) regression was selected as the most appropriate tool. In the 2009 study a combination of one way analyses of variances (ANOVA) and OLS regression were chosen. The ANOVAs were selected to evaluate hypotheses H_{1a}, H_{1b}, H_2, H_3, and H_4. Before hypotheses H_{3a1}, H_{3a2}, H_{3b} H_{4a1}, H_{4a2}, and H_{4b} could be evaluated H_3 and H_4 needed to establish whether shared ownership had any effect on resource utilization and/or shared mental models. When the tests did not support the existence of significant differences between the control and test groups, and shared ownership was not found to affect resource utilization and/or shared mental models, OSI regression was used to evaluate the hypotheses H_{3a1}, H_{3a2}, H_{3b} H_{4a1}, H_{4a2}, and H_{4b}. When no significant differences were found and shared ownership was shown to have no effect on resource utilization and/or shared mental models, OLS regression was again used, but instead of measuring the mediating affects of shared ownership, it was used to measure the direct effect of shared mental models and resource utilization on team performance and team member satisfaction.

To ensure that aggregation of individual survey responses to team-level responses was appropriate, an analysis of variance (ANOVA) was performed. The variance observed at the team and individual level were compared. To check for alternate explanations of significant findings, post hoc analyses were completed. In both the 2008 and the 2009 studies an analysis comparing the OSU to the VT students. In the 2009 study demographic survey data was also assessed to see if there were any trends in the data specific to the gender of the participants, student status (i.e. undergraduate vs. graduate), the proficiency students had speaking English (i.e. students who spoke English as their first language vs. students whose native language was not English), and lastly experience working in virtual teams (i.e. students new to virtual teams vs. students with past experience working on a virtual team). One-way ANOVAs were chosen as the most appropriate statistical tool to evaluate the differences between survey results, when

demographic factors were taken into account. When assumptions for the ANOVA were violated, nonparametric tests were used run.

All assumptions for each statistical test were checked. For the two sample t-tests the normality of the data, equality of variance between data sets, and independence were verified (Ramsey & Schafer, 2002). Prior to performing OLS regression normality of the errors and ~N(0,σ), equality of variance, and independence were verified, along with a graphical assessment to ensure that the data being regressed were linearly related (Ramsey & Schafer, 2002).

3.2 Qualitative Methods

Qualitative data, in both the 2008 and 2009 study, was collected. Students in both studies were asked to share copies of electronic communications created by the team while working on the virtual team project. These communications included emails, meeting notes, meeting agendas, Facebook correspondence, and meetings held on MSN Messenger. The data collection methods used in the 2008 and 2009 studies were slightly different and therefore are described separately in more detail in 3.4.1 and 3.4.2. After all of the qualitative material had been collected, the analysis began. The first step in the analysis was to develop a coding scheme. A code in qualitative research is an abbreviation or symbol applied to a segment of words, most often a sentence or paragraph of transcribed field notes, in order to classify the words (Miles & Huberman, 1984). The codes developed for this study were used to help identify the existence of each dependent variable within the qualitative data. In both studies, all of the qualitative data were analyzed and coded. Miles and Huberman (1984) state that a valid qualitative analysis requires, and is driven by, displays that are focused and are systematically arranged. Further they state that there is no agreed-upon optimal way to display qualitative data and "formats can be as various as the imagination of the analyst, but they usually turn out as a summarizing table (matrix, chart, checklist), or figure" (Miles & Huberman, 1984, p. 79). For this research, a matrix was used to summarize all coded

material. Matrices offer the researcher the ability to visually assess the summarized data and to determine if common themes or contrasting themes are present. The matrix also enables more refined analyses and can lead to the creation of additional displays and more analyses (Miles & Huberman, 1984). The matrix display created for this research included six columns. One column includes a team identifier, one column includes a summary of the interaction or communication, one column identifies the team member(s) who participated in the communication, one column lists the number of occurrences per contributor of the summarized material, one column lists the date of each occurrence, and the final column lists the communication media used during the interaction. An example of the matrix display used is shown in Table 16. The completed matrix displays, from both the 2008 and 2009 studies, can be found in Sections 4.1.2 and 4.2.2.

Table 16

Example matrix display

VT Number	Summary of Coded Data	Contributor(s)	Occurrences/Contributor	Date of Occurrence(s)	Source
Team A	Example: Comment to include everyone	#1	#1= 4	#1= 2/13 x2, 2/22, 3/1	Email
		#5	#5= 1	#5= 2/23	MSN Messenger
Team C	Example: Discuss leveraging team member resources	#2	2	2/10, 21/8	Email

After all the data were summarized in matrices, the next step was to analyze the data. A multitude of tactics, common to qualitative analysis, were used in analyzing the displays. Patterns and themes were looked for; logical chains of evidence were identified;

plausibility analyses were considered; relationships between variables were noted; efforts were made to identify significant variables initially overlooked; and the dependent variables were evaluated to see if they should be split into multiple components (Miles & Huberman, 1984).

Patterns and themes in the data can demonstrate the existence, or lack thereof, of a phenomena within the data. For instance if every team in a qualitative study indicated that they had trouble using an available technology, this pattern of trouble with the technology might be used to demonstrate how the low quality work produced by the teams was not a result of the teams being made up of "lazy" or "incapable" workers, but instead as a result of limitations inherent to the technology being used. Logical chains of evidence occur in an analysis when two or more variables appear to be associated with each other according to the conceptual expectations or preliminary understanding of the research being performed. A plausibility analysis is when certain conclusions may be justified without concrete reason or cause. It can often happen that during an analysis a conclusion is plausible, makes good sense, or just fits. If a colleague of the researcher were to question what the conclusion was based upon, the only honest response would be "I don't know….. It just feels right" (Miles & Huberman, 1984).

Relationships between the data were also analyzed. Attention was paid to see if any of the dependent variables in both the 2008 and 2009 study could be split into multiple variables that would offer more fruitful results. For example in an analysis it might make more sense to split a variable titled "individual preparedness' into two variables: "amount of preparation" and "competency with required skill sets." Lastly the primary researcher made special efforts to keep an open mind during the analysis and to not overlook any variables significant to the research not originally included in the design of the research model.

3.3 Variables

The variables of interest in this research have been studied across a variety of disciplines. As a result multiple definitions exist for each of these variables. Because of this, it was necessary to operationalize each variable for the purpose of this research.

3.3.1 *Independent Variable*

The independent variable tested in this study was shared ownership. Shared ownership was operationalized as the extent to which virtual team members believe they are equally responsible and accountable for a project deliverable in which they receive the same evaluation[1].

3.3.2 *Mediating and Dependent Variables*

The mediating variables of the study included resource utilization and shared mental models. The dependent variables were team performance and team member satisfaction. Resource utilization was operationalized as the extent to which a team effectively utilizes key resources, including team member knowledge. Shared mental models were operationalized as the degree to which team members have a common understanding of the team's objectives/goals, as well as a strategy for reaching the objectives/goals. Team performance was operationalized as the quality of work a virtual team produces. This was measured in two ways, objectively and subjectively. Objective team performance was measured using the final project grade each virtual team received. Subjective team performance was operationalized as an aggregated team member evaluation of the quality of the team's work. Team member satisfaction was operationalized as the aggregated team member evaluation of the individual satisfaction resulting from the virtual team experience.

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1. After the completion of this study, it was realized that the definition of shared ownership did not adequately reflect the author's intent. This is discussed further in Chapter 5.

3.3.3 *Creating differing levels of Shared Ownership*

A team charter was used as the intervention mechanism in an attempt to create different levels of shared ownership between different virtual teams. A team charter is a written document that defines a variety of behavioral and performance expectations and team member information including team member skills, ground rules, and team standards for availability. Other information deemed applicable to the effective and efficient functioning of a team is also included in the charter document. A charter document was chosen as the intervention mechanism because it is developed by a team at the beginning of a virtual team's life.

Two team charter assignments (i.e. Charter Assignment-A and Charter Assignment-B) were developed in the effort to force different levels of shared ownership between the teams participating in this research. Charter Assignment-A was developed in a way that was anticipated to create lower levels of shared ownership than Charter Assignment-B. Charter Assignment-A required only minimal team-level work. In particular, Charter Assignment-A required student teams to discuss and evaluate fewer team-level behaviors and processes than Charter Assignment-B. Charter Assignment-B required the teams to more thoroughly evaluate team processes and to evaluate more aspects of team processes and behaviors. The additional sections required in Charter Assignment-B were intended to create higher levels of shared ownership for teams than Charter Assignment-A.

3.4 Data Collection and Analysis

The research was performed in two stages. The data collection in the first stage was conducted in the 2008 study. The data collection for the second stage was conducted in the 2009 study. The 2008 study had two objectives. The first objective was to develop, test, and validate a survey instrument for measuring the dependent variables. The second objective of the 2008 study was to assess if the second stage of the research (the 2009 study), was worth pursuing. This was done by testing to see if the hypothesized effects of shared ownership (i.e. that shared ownership would positively impact resource utilization

and the development of shared mental models) would affect team performance and team member satisfaction. The 2009 study's objective was to evaluate the validity of the following research hypotheses:

H_{1a}: Shared Ownership has a direct relationship with Subjective Team Performance

H_{1b}: Shared Ownership has a direct relationship with Objective Team Performance

H_2: Shared Ownership has a direct relationship with Team Member Satisfaction

H_3: Shared Ownership has a direct relationship with Resource Utilization

H_{3a1}: The relationship between Shared Ownership and Subjective Team Performance is mediated by Resource Utilization

H_{3a2}: The relationship between Shared Ownership and Objective Team Performance is mediated by Resource Utilization

H_{3b}: The relationship between Shared Ownership and Team Member Satisfaction is mediated by Resource Utilization

H_4: Shared Ownership has a direct relationship with Shared Mental Models

H_{4a1}: The relationship between Shared Ownership and Subjective Team Performance is mediated by Shared Mental Models

H_{4a2}: The relationship between Shared Ownership and Objective Team Performance is mediated by Shared Mental Models

H_{4b}: The relationship between Shared Ownership and Team Member Satisfaction is mediated by Shared Mental Models

Both studies were conducted using student teams, composed of team members who were peers. Teams did not have a designated team leader. Participants were students enrolled at Oregon State University (OSU) or at Virginia Polytechnic Institute and State University (VT), and who were enrolled in an engineering management course. The course instructors from OSU and VT jointly managed the virtual teams and collaborated to develop the virtual team project. The students from OSU came from the school of Mechanical, Industrial, and Manufacturing Engineering's Engineering Management Course (i.e. IE470/570). This course teaches methods of improving organizational

performance through the design and implementation of systems that integrate personnel, technological, environmental, and organizational variable as described by OSU's course catalog. The VT students came from the Industrial Systems Engineering department's Management of Organizational Systems Course (i.e. ISE5016), which teaches the management (planning, measurement and evaluation, control, and improvement) of organizational systems (work groups, departments, functions, plants, and companies); as described by VT's course catalog. Student demographics specific to the individual studies are described in section 3.4.1 for the 2008 Study and in section 3.4.2 for the 2009 Study.

The students from OSU were a mixture of graduate and undergraduate students, while the students from VT were all graduate students. Students from both universities were assigned to each virtual team. The student virtual teams worked on the project across seven weeks in 2008, and across five weeks in 2009. The performance measurement system design project was assigned as part of the requirements for each course, in both the 2008 and 2009 study. In both years, the objective of the virtual design project was for each team to create a performance measurement system for an organization of their choice.

The assignment was titled a "virtual performance measurement design project." The project included three deliverables: an initial "target organizational system identification", a "virtual team charter document," and an "organizational performance measurement system design report." Appendix C includes a copy of the project assignment given to the students in both the 2008 and 2009 studies. The deliverable associated with the target organizational identification task was a single email from a virtual team describing the chosen organization. This email was sent to both the OSU and VT instructors one week after the assignment was assigned. The email was to identify the selected organization and was to include a short paragraph describing the nature of the selected organization and a brief summary explaining the rationale for the group's selection. Sections 3.4.1 and 3.4.2 describe the different virtual team charter assignments used in the two studies. The final deliverable of the virtual team project was an

organizational performance measurement system design report. This report included six sections. The first section, titled "Need for Measurement," required that the students define why a performance measurement system would be valuable for their selected organization. In the second section, titled "Suppliers-Inputs-Processes-Outputs-Customers (SIPOC) Diagram," students were asked to create a SIPOC diagram. In the next section, titled "Mission Statement," students were required to include a mission statement describing the selected organization's core focus, based on the team's analysis. In the fourth section, titled "Strengths-Weaknesses-Opportunities-Threats (SWOT) Analysis," teams were required to perform a SWOT Analysis on their selected organization, identifying the strengths, weaknesses, opportunities and threats present within their selected organization. In the fifth section, titled "Metrics," teams were required to develop two metrics for each of the four defined dimensions of performance. The four performance dimensions were based on a balanced scorecard framework and included financial, customer, internal processes, and innovation and learning. Each team was not only required to develop eight metrics for their selected organization, but students were also charged with evaluating the quality of their metrics and determining how their selected organization should use each metric. Finally in the sixth section, titled "Measurement System Audit," students were required to map the eight metrics developed against two frameworks: first against the five dimensions of SIPOC and secondly against a measurement framework of the students' choice, such as the Malcolm Baldrige National Quality Award.

3.4.1 *The 2008 Study*

In the 2008 study the data used was not collected by the author, rather the data was obtained from a study that was conducted in 2008. The raw data from the study, both quantitative and qualitative, was obtained from a researcher from the original study. There were a total of 73 students enrolled in the OSU or VT course, with 50 coming from OSU and 23 from VT. Students from OSU were all from OSU's main campus and were all undergraduate students. Of the 23 students from VT, 20 were from VT's main campus

and three were from VT's Northern Virginia Center. All VT students were graduate students. Eleven teams were created out of the 73 students. Each team consisted of six to seven students, with two to three students coming from VT on each virtual team and four to five from OSU. Students were informed of the project during the first day of class and had a formal discussion regarding the project on 1/28/2008. Project deliverables were due in the third week of the project on 2/15/2008 (i.e. the Target Organizational System Identification), in the fourth week of the project on 2/22/2008 (i.e. Virtual Team Charter Document), and in the seventh week of the project on 3/14/2008 (i.e. the Organizational Performance Measurement System Design Report). All teams were asked to complete the same set of virtual project assignments. Because of this it was assumed that the level of shared ownership was the same for the eleven teams.

Quantitative data was collected through the administration of the 2008 survey and by acquiring the final grades each team received on the project. The survey was voluntary, and participating students were informed not to provide their name on the survey to maintain confidentiality. However, students were asked to provide a team number. The survey was administered to participants during the last 10-15 minutes of class. Before the surveys were administered, the course professor read a brief script to the class. The script contained background information on the research being conducted, instructions for completing the survey, and contact information. Students who did not wish to participate were told that they could leave class early. Each survey consisted of 43 survey items, 31 items assessed relationship building, resources utilization, conflict resolution, perceived team performance, team member satisfaction, technology use, the establishment of shared mental models, team trust, and the availability of required resources. The 31 items assessing the virtual team related constructs were all measured on a six-point Likert scale, with values of 1 indicating strong disagreement with the statement and values of 6 indicating strong agreement with the statement in the survey. Eleven of the questions asked for students to quantify their use of different communication technologies based on frequency of use. The last item was open-ended, requesting general comments from the students. A copy of the survey, cover sheet and

script used in the study can be seen in Appendix D. The data for the objective performance values were obtained from the OSU professor who taught the course.

Quantitative analysis was performed with the use of two software packages (i.e. Microsoft Excel and SPSS). Microsoft Excel was used to organize all of the data and to calculate summary statistics (i.e. averages and standard deviations) for each variable. SPSS was used to calculate the internal consistency of each construct. SPSS was also used to perform regression analysis.

The first task in the analysis was to assess the reliability of each construct. Of the 31 survey items, 15 were deemed consistent with the constructs used in this research; four items evaluated resource utilization, five items evaluated the establishment of shared mental models, four items evaluated team member satisfaction, and two evaluated team performance. Cronbach's alphas were calculated and upon review of the analysis it was recognized that the removal of two survey items would result in a more reliable evaluation of the dependent variables. The two survey items removed were "knowledge and information sharing was understood to be a group norm for our team" (resource utilization) and "team member morale was high" (team member satisfaction). Table 17 shows the resulting survey items used to measure each of the dependent variables.

Table 17

Survey items used for each dependent variable in the quantitative analysis

Resource Utilization
Team members trusted one another and consulted with each other throughout the project
Our team was a very cohesive unit
Team members recognized our collective talents
Shared Mental Models
During our team's first meeting; some time was dedicated to discussing the team's purpose and goals
Our team dedicated some time during project meetings to team building exercises
Team members experienced a sense of shared goals and objectives
Team members had a shared understanding of the project's goals and objectives
Our team used an established process for making decisions
Team Member Satisfaction
I felt my input was valued by members of this team
I enjoyed being a member of this team
In the future; I would be interested in participating in another virtual team
Performance
Our team completed tasks on time
Our team met the deadlines we set for ourselves

ANOVA was completed next, using the combined survey items for each variable. ANOVA was used to determine if within team variation was less than the variation between teams. Prior to performing the ANOVA the assumptions of the test were assessed, checking for normality, independence, and equal variance. Regression analyses followed. Prior to performing the regression analysis the assumptions for OLS regression models were evaluated and included, checking for normality of the error terms, equal variances, independence of means, and the existence of linear relationships between variables.

Qualitative data was collected on 3/12/2008, two days prior to the due date of the final project report. Students were given six points of extra credit on the final project

deliverable (10% of the total grade) to provide a copy of the team's electronic communication, including emails and chat room discussions, to the instructor. Five out of the 11 teams participated and provided records of the team's communications. The data analysis began by creating a coding scheme to organize the data. The four dependent variables were used as the framework for the codes. Each code indicated that a communication signified the existence or development of one of the dependent variables. Once the data was coded it was then summarized and displayed in a matrix display. The matrix display and results from the quantitative analysis were then compared with the 2008 survey results.

3.4.2 *The 2009 Study*

In the 2009 study, the first task performed was the creation of the 2009 survey instrument. The survey instrument used in the 2008 survey had shown that reliable constructs could be created to measure the dependent variables (i.e. all Cronbach's alpha values >0.70). Based on the literature review and the operationalization of the survey constructs, additional survey items were developed to fully characterize the constructs. Survey items from the 2008 were considered in the development of the 2009 survey.

To develop the survey for the 2009 study not only were survey items from the 2008 survey instrument used, but also when appropriate survey items were developed by the researchers. Each construct was created for each of the four dependent variables. Each variable's operationalized definition served to define the construct. To ensure construct reliability and validity it was decided to use at least four survey items per construct.

Next the survey items were selected and/or developed for the 2009 survey. Three of the survey items from the 2008 survey were chosen as offering an accurate representation of the operationalized definitions for the 2009 survey. These survey items were "Team members recognized our collective talents" measuring resource utilization, and "I enjoyed being a member of this team," and "In the future, I would be interested in

participating in another virtual team" for team member satisfaction. These items offered a close representation of the operationalized definitions developed. To further improve the validity of the items, small changes to the wording were made. Table 18 presents the three items taken from the 2008 survey and displays how each item was adapted for use in the 2009 study.

Table 18

2008 Survey items adapted for the 2009 survey

Original Survey item
Team members recognized our collective talents.
Adapted for the 2009 survey
My team has a good understanding of each other's task-related knowledge.
My team has a good understanding of each other's task-related skills.
My team takes advantage of all the specialized knowledge each team member possesses, relevant to the project.
My team takes advantage of all the specialized skills each team member possesses, relevant to the project.
Original Survey Item
I enjoyed being a member of this team.
Adapted for the 2009 survey
I enjoy working with my team.
Original Survey Item
In the future; I would be interested in participating in another virtual team.
Adapted for the 2009 survey
I'd like to work with my team again.

The ten remaining survey items were developed by the author. All 16 survey items from the 2009 survey were measured on a five-point Likert scale, with values of a 1 indicating strong disagreement and values of a 5 indicating strong agreement. The survey ended with five items capturing demographics information on the participant. Table 19 summarizes the all of the survey items used to measure each construct in the 2009 survey and indicates whether the survey item was adapted from the 2008 survey or created by

the primary researcher. A complete copy of the survey instrument and the cover sheet used in the 2009 study can be seen in Appendix D.

In the 2009 study, quantitative data was collected via the primary researcher. There were a total of 75 students who were enrolled in either the OSU or VT course with 45 from OSU and 30 from VT. Students from OSU were all from OSU's main campus and were a mixture of graduate and undergraduate students, with 14 being graduate students and 31 being undergraduate students. Of the 30 students from VT, 28 students were from VT's main campus and two were from VT's Northern Virginia Center; all VT students were graduate students. Sixteen teams were created out of the 75 students. Each team consisted of four to five students; with one to two students coming from VT and two to three from OSU.

Students were informed of the project in their first day of class, and had a formal discussion regarding the project on 2/2/2009. Project deliverables were due in the second week of the project on 2/11/2009 (i.e. the Target Organizational System Identification), in the third week of the project on 2/18/2009 (i.e. Virtual Team Charter Document), and in the fifth week of the project on 3/6/2009 (i.e. the Organizational Performance Measurement System Design Report).

Table 19
Constructs used to measure each dependent variable (2009 Study)

Resource Utilization
My team has a good understanding of each other's task-related knowledge[2]
My team has a good understanding of each other's task-related skills[2]
My team takes advantage of all the specialized knowledge each team member possesses, relevant to the project[1]
My team takes advantage of all the specialized skills each team member possesses, relevant to the project[1]
Team Member Satisfaction
I enjoy working with my team[2]
I really feel that I am a part of my team[1]
I have learned a lot from the other members of my team[1]
I'd like to work with my team again[2]
Shared Mental Models
My team has a clear understanding, shared by all team members, of how information should be communicated[1]
When communicating, my team members are careful to ensure that all information transmitted can easily be understood[1]
My team has a shared understanding of how each team member can best contribute to the project[1]
My team has a clear understanding, shared by all team members, of what all is needed to complete our project[1]
Performance
The work my team has produced so far is exceptionally good[1]
The final project deliverable will be exceptionally good[1]
My team will earn an A on this project[1]
My team performed to the best of our ability[1]

[1] Indicates a survey item created by the primary researcher

[2] Indicates a survey item that was adapted from the 2008 survey

Two charter documents were created for the purposes of the 2009 study (i.e. Charter Assignment-A and Charter Assignment-B). It was hypothesized that by creating the two charter documents, two levels of shared ownership could be established within the virtual teams participating in the study. For the first team charter, Charter Assignment-A, the

same charter document from the 2008 study was used. It required the student teams to establish group objectives, an overview of the selected organization, group processes, team roles, and principles of operation. The second team charter, Charter Assignment-B, was created with the intent to force teams to more thoroughly develop an understanding of team processes that are critical to working on a virtual team. Charter Assignment-B required the virtual teams to establish team goals, individual skills inventories, team ground rules, potential barriers and coping strategies, conflict management strategies, standards for availability, the personality types and learning styles within the team, and a brief overview of the organization the virtual team had selected for the project. Each team charter was evaluated on the same scale (worth a maximum of 10 points), and each virtual team was randomly assigned one of the two charter assignments. Copies of each charter assignment and the grading rubric used to evaluate charters are included in Appendix E.

Quantitative methods were used to test the study's hypotheses. The quantitative data was collected by obtaining the final grades each team received on their projects and through the administration of the 2009 survey. After all of the virtual teams had completed the projects, and the projects had been graded and handed back to the students, team grades were obtained from the OSU professor. The survey was administered to the students on 3/11/2009, the week following the submission deadline for the virtual team projects. The completion of the survey was voluntary. The participating students were informed not to include their name on the survey to maintain confidentiality. However, students were asked to indicate their team number on the survey. The survey was administered to participants during the last 15 minutes of their class. Before the surveys were administered, a brief script was read to each class. At OSU the script was read by the primary researcher. At VT the script was read by a volunteer graduate student at VT. The script contained background information on the research being conducted, instructions for completing the survey, and contact information. A copy of the script is included Appendix D. Students who did not wish to participate in the survey were told that they could leave class early.

Of the 75 students who were enrolled in the courses, 60 chose to participate in the survey. Of the 60 students, two individuals chose not complete the demographic section. Out of the 58 students who did complete the demographic information, 14 were females and 44 were males. The mixture of graduate students to undergraduate students was 32 graduate to 26 undergraduate students. The age range of the students was between 21 and 35 years. Eighteen of the students indicated that English was not their first language, and 15 of the students indicated that they had past experience working in virtual teams.

Quantitative analysis was performed using three statistical software packages (i.e. Microsoft Excel, SPSS, and Statgraphics), the data was analyzed. Microsoft Excel was used to organize all of the data and to calculate summary statistics for each variable (i.e. averages and standard deviations). SPSS was used to calculate the internal consistency of the variables measured in the survey, to perform the comparison of means analyses, and to perform most of the regression analyses. Statgraphics was used in conjunction with SPSS to help check assumptions of the statistical models and to perform some of the regression analyses.

To evaluate the appropriateness of aggregating the analysis to a team level analysis, an ANOVA was performed. The ANOVA was used to assess whether or not group-level differences were significantly different than individual differences. To evaluate the hypotheses, H_{1a}, H_{1b}, H_2, H_3, and H_4, an ANOVA was used. The assumptions of tests were verified including checking for normality, equal variances, and independence. To evaluate the hypotheses, H_{3a1}, H_{3a2}, H_{3b}, H_{4a1}, H_{4a2}, and H_{4b}, OLS regression was used. The assumptions for OLS regression model were all verified, including checking for normality of error terms, equal variances, independence of the data, and the existence of a linear relationship between the variables being regressed. After all assumptions were verified, regression analysis was completed.

To check for alternate explanations of significant findings, post hoc analyses were completed. In both the 2008 and the 2009 studies an analysis comparing the OSU to the

VT students. In the 2009 study demographic survey data was also assessed to see if there were any trends in the data specific to the gender of the participants, student status (i.e. undergraduate vs. graduate), the proficiency students had speaking English (i.e. students who spoke English as their first language vs. students whose native language was not English), and lastly experience working in virtual teams (i.e. students new to virtual teams vs. students with past experience working on a virtual team). One-way ANOVAs were chosen as the most appropriate statistical tool to evaluate the differences between survey results, when demographic factors were taken into account. When assumptions for the ANOVA were violated, nonparametric tests were used run.

The qualitative data for the 2009 study was collected during the 6 months after the teams had completed the projects. It was gathered by asking students to voluntarily provide the documented communications they had saved or had records of to the primary researcher of this document. Unlike the 2008 study, students were not given extra credit for providing copies of their team's electronic communication. Only one out the 16 teams participated by providing the records of all of the team's email correspondence during the virtual team project. The analysis began by taking the framework developed in the 2008 study and applying it to the qualitative data gathered in the 2009 study. The same coding scheme was used, creating four constructs to measure each of the dependent variables (i.e. resource utilization, shared mental models, team performance and team member satisfaction). Once the data was coded a matrix, display was developed. The matrix display and results from the quantitative analysis were then compared with the 2009 survey results.

4 Results

In this chapter the results from the analysis of the 2008 and 2009 study are discussed.

4.1 The 2008 Study

Table 20 below includes descriptive statistics for the data obtained from the 2008 study. A total of 73 students participated in virtual team projects. Virtual teams were made up of six to seven students. Of the 73 who participated in virtual team projects, 50 chose to complete the survey.

Table 20

Descriptive statistics: Team values (2008 study)

Team #		Resource Utilization		Shared Mental Models		Member Satisfaction		Subjective Performance		Objective Performance	
	n	Mean	St Dev	Mean	St Dev	Mean	St Dev	Mean	St Dev	Mean	St Dev
1	7	5.19	0.75	4.91	1.06	5.43	0.60	5.64	0.50	5.60	-
2	3	5.00	1.12	4.80	1.21	4.50	1.05	5.50	0.84	5.50	-
3	2	4.67	0.52	4.50	0.71	4.50	1.05	4.50	0.58	5.60	-
4	5	4.73	0.70	4.25	1.07	5.00	0.65	5.10	0.74	5.60	-
5	4	3.33	1.15	3.53	1.47	4.33	1.78	3.75	1.98	5.50	-
6	4	5.00	0.60	4.70	1.22	5.25	0.75	5.63	0.52	5.60	-
7	5	4.21	1.19	4.00	1.44	4.73	0.96	5.80	0.42	5.20	-
8	5	4.87	0.99	4.64	1.35	4.67	1.11	5.60	0.97	5.50	-
9	5	4.87	0.92	4.88	0.93	5.33	0.72	5.00	0.94	5.90	-
10	4	5.42	0.51	5.25	0.79	5.64	0.67	5.88	0.35	5.70	-
11	5	4.00	1.36	3.88	1.17	4.27	1.44	4.60	0.84	5.10	-
All Teams		4.69	1.08	4.49	1.24	4.96	1.06	5.23	1.03	5.53[1]	0.22[1]

4.1.1 *Quantitative Analysis*

In this section, the results from the 2008 study's quantitative analysis are discussed.

4.1.1.1 *Survey Reliability and Validity*

To check the internal-consistency or reliability of the survey constructs, Cronbach's alpha was calculated. The Cronbach's alpha value for each construct is presented in Table 21. All constructs were reliable, with all alphas ≥0.70 (Nunnally, 1978).

Table 21

Cronhach's alpha: 2008 survey Instrument

Variable	Number of Survey Items	n	C_α
Resource Utilization	3	49	0.78
Shared Mental Models	5	47	0.80
Team Member Satisfaction	3	49	0.81
Team Member Performance (Subjective)	2	50	0.78

4.1.1.2 *Aggregation of Survey Responses (2008 Study)*

Since the data collected was assessing perceptual measures, it was necessary to collect data at the individual-level (i.e. individuals within teams). Survey items were designed to reflect group-level attributes, thus the group was used as the referent in all survey items. If the measures work as designed there should be more variation across teams than within teams and there should be a relatively high degree of consensus within teams. An ANOVA was used to assess whether or not within team variation was lower than between team variation. Table 22 presents the results of this ANOVA.

Table 22

ANOVA analysis: Aggregation of Survey Responses (2008 Study)

		Sum of Squares	df	Mean Square	F	Sig.
RU	**Between Teams**	15.660	10	1.566	2.944	.008
	Within Teams	20.210	38	.532		
	Total	35.870	48			
SMM	**Between Teams**	11.704	10	1.170	2.697	.013
	Within Teams	16.488	38	.434		
	Total	28.192	48			
P_Sub	**Between Teams**	18.169	10	1.817	2.953	.008
	Within Teams	23.382	38	.615		
	Total	41.551	48			

RU = Resource Utilization

SMM = Shared mental model data

P_Sub = Subjective performance

Group level differences were significant (p-value $\leq$.05) for all variables. All variables included on the virtual team survey were measured at the individual level. The unit of study, however, was at the team level. An aggregation of individual-level data to produce team-level data should occur only if there is a theoretical rationale for doing so. In this study, the results from the ANOVA analysis indicated that there were significant differences between the individual-level and team-level responses. These results provided additional support for aggregating data at the team level. In addition, all survey items were developed referring to the team as the unit of interest, e.g. "My team has a good understanding of each other's task-related knowledge. ANOVA was not completed for those survey items related to team member satisfaction. The team member satisfaction items used the individual as the referent since the intent of the team member satisfaction construct was to capture individual-level satisfaction.

4.1.1.3 *Correlation Analysis*

To assess the presence of relationships between the variables in this study, a correlation analysis was performed. Pearson's correlation coefficient was chosen as the correlation statistic for the analysis. Table 23 presents the results of the correlation analysis for the mediating and dependent variables. Both of the mediating variables (i.e. resource utilization and shared mental models) were found to be highly correlated to each other. Of the dependent variables team member satisfaction was found to be correlated to both subjective performance and objective performance. However, subjective performance and objective performance were not found to be correlated with each other at a significant level.

Table 23

Correlation analysis: Mediating and dependent variables (2008 Study)

		RU	SMM	TMS	P_Sub	P_Obj
RU	**Pearson Correlation**	1	.962	.745	.771	.554
	Sig. (2-tailed)		.000	.009	.005	.077
	N	11	11	11	11	11
SMM	**Pearson Correlation**	.962	1	.755	.682	.654
	Sig. (2-tailed)	.000		.007	.021	.029
	N	11	11	11	11	11
TMS	**Pearson Correlation**	.745	.755	1	.617	.659
	Sig. (2-tailed)	.009	.007		.043	.028
	N	11	11	11	11	11
P_Sub	**Pearson Correlation**	.771	.682	.617	1	.088
	Sig. (2-tailed)	.005	.021	.043		.798
	N	11	11	11	11	11
P_Obj	**Pearson Correlation**	.554	.654	.659	.088	1
	Sig. (2-tailed)	.077	.029	.028	.798	
	N	11	11	11	11	11

RU = Resource Utilization

SMM = Shared Mental Models

TMS = Team Member Satisfaction

P_Sub = Subjective Performance

P_Obj = Objective Performance

4.1.1.4 *Regression Analysis*

To assess the effects of shared mental models and resource utilization on team performance and team member satisfaction ordinary least squares (OLS) regression was used. Prior to performing the regression the assumptions were checked. These assumptions include a need for normally distributed errors, non-correlated errors, independence, and lastly linearly related data.

The normality and level of correlation between the errors was checked first. Scatter plots were created of the residuals versus fitted values. Figure 3 shows the corresponding residual plots.

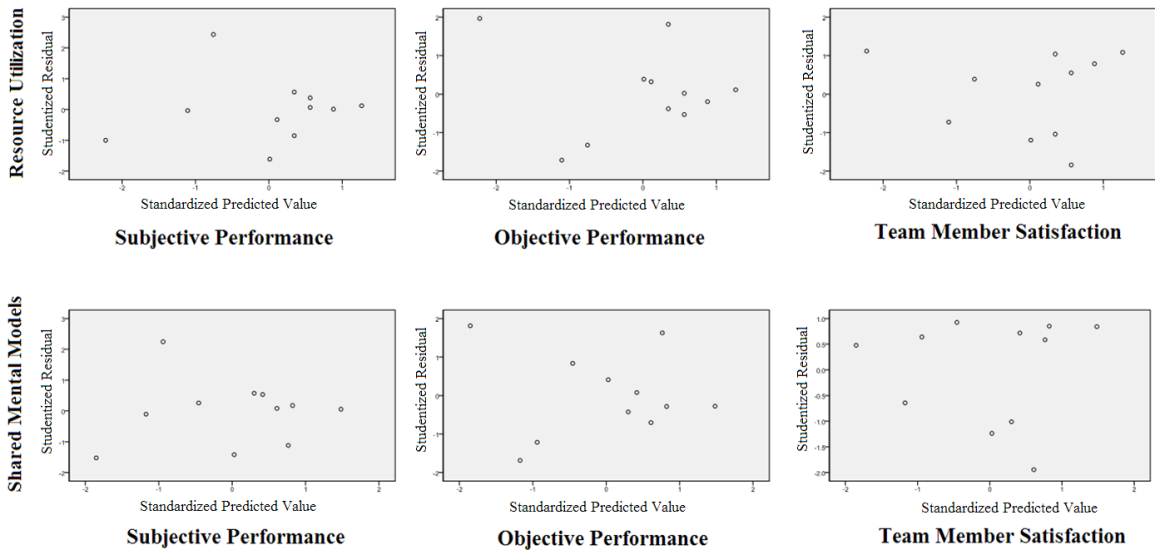

Figure 3: Regression analysis: Plot of residuals versus fitted values (2008 Study)

Upon review of the residual plots in Figure 3, the assumption of normally distributed errors and the assumption of non-correlated errors appear reasonable. The independence assumption was also reasonable. Each virtual team in the study was made up of students who participated on only one team, and each team was held liable only for the work that their own team produced. To check for linearity, scatter plots were created for each of the regression analyses to be performed. Figure 4 displays the scatter plots of the mediating variables against each of the dependent variables.

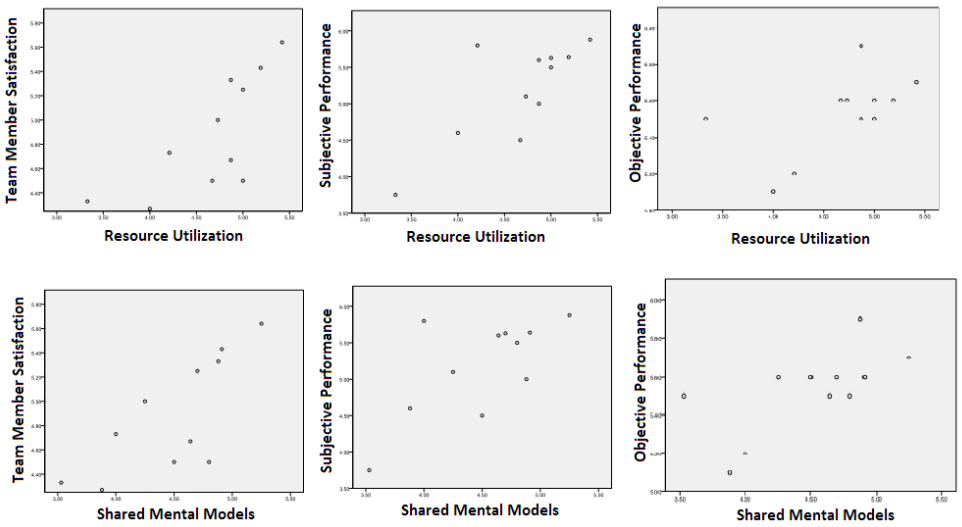

Figure 4: Regression analysis: Scatter plots (2008 Study)

As can be seen from Figure 4, the assumption of linearity appears to be a reasonably met. The results of the OLS regression are summarized in Table 24.

Table 24

Ordinary Least Squares Regression (The 2008 study)

Variable	Subjective Performance				Objective Performance				Team Member Satisfaction			
	β_0	β_1	R^2	P-value	β_0	β_1	R^2	P-value	β_0	β_1	R^2	P-value
Resource Utilization	1.18	0.86	0.59	0.005	4.6	0.20	0.31	0.077	2.12	0.59	0.55	0.009
Shared Mental Models	1.22	0.88	0.47	0.021	4.3	0.28	0.43	0.029	1.75	0.70	0.57	0.007

Both resource utilization and shared mental models were found to be related to team performance and team member satisfaction. Resource utilization was found to be related to subjective performance and team member satisfaction. However, resource utilization was not related to objective performance. Shared mental models were significantly related to all three of the variables (i.e. subjective performance, objective performance, team member satisfaction).

4.1.2 *Qualitative Analysis*

The qualitative analysis performed in the 2008 study was based on the resources student participants made available to the researchers at the end of the academic quarter. In the 2008 study a total of five teams provided their electronic communications. The data collected was in the form of emails, meeting notes, meeting agendas, Facebook correspondence, and meeting transcripts taken from MSN Messenger.

The teams who provided notes were team 3, 5, 6, 8 and 9. Team 3 shared copies of their email correspondence from the virtual team project. Team 5 shared copies containing a majority of the team's email correspondence, along with a copy of one meeting agenda and the meeting notes from that meeting. Team 6 shared the notes from all of the team's meetings. However, these notes were very brief and did not offer enough content to be used in the analysis. Team 8 shared a portion of the team's emails, along with copies of the team's Facebook correspondence, and copies of four meetings that were held on MSN Messenger. Lastly team 9 shared meeting agendas from four of the team's meetings, and four sets of notes. The notes from the team's final meeting and the agenda from the team's first meeting were not provided.

The purpose of the qualitative analysis was to provide an additional lens to help evaluate the 2008 quantitative analysis. The analysis focused on identifying evidence of each dependent variable. The role of the analysis was to validate team-level values for the dependent variables. Table 25 summarizes the average values for teams 3, 5, 8, 9, the overall average value for all the teams, and the highest and lowest team value for all of the teams.

Table 25

Summary statistics for qualitative analysis: team values (2008 Study)

	Team #	Resource Utilization	Shared mental Models	Team Member Satisfaction	Subjective Performance	Objective Performance
Individual Teams	3	4.67	4.50	4.50	4.50	5.06
	5	3.33	3.53	4.33	3.75	5.50
	8	4.87	4.64	4.67	5.60	5.50
	9	4.87	4.88	5.33	5.00	5.90
All Teams	Average	4.69	4.49	4.96	5.23	5.53
	High	5.42	5.25	5.64	5.88	5.90
	Low	3.33	3.53	4.27	3.75	5.10

4.1.2.1 *Resource Utilization*

In this section resource utilization for teams 3, 5, 8, and 9 are compared and contrasted based on the quantitative data collected.

4.1.2.1.1 *Resource Utilization for Team 3*

The evidence related to resource utilization for team 3 is summarized in Table 26. Team 3 appeared to maximize the utilization of the team's resources. Early on in the project, six of the seven team members shared short self-descriptions with the team. On one occasion a comment was made to ensure that everybody was being included in a decision, and on another occasion there was a mention of the need to define team roles. On two occasions discussions were held focused on trying to leverage unique team member resources. On three separate occasions, each prior to an approaching deadline, attempts were made make sure that everybody was included and comfortable with the status and direction of the project.

Table 26

Matrix display: Evidence of the of resource utilization within team 3 (2008 Study)

Team #	Summarized Material	Contributor(s)	Occurrences	Date of Occurrence(s)	Source
Team 3	Early in project: comment to include everyone	#3	1	2/15	Email
	Leveraged unique team member resource	ET[1]	2	2/15 (x2)	Email
		#5	1	2/6	Email
	Explicit attempts to include all team members	#3	2	2/21, 3/4	Email
		#5	1	2/13	Email
	Early in the project: created personal self-descriptions and emailed to entire team	#1	1	2/11	Email
		#2		2/11	Email
		#4		2/5	Email
		#5		2/5	Email
		#6		2/4	Email
		#7		2/5	Email
	Early in Project: address need to define roles	#2	1	2/11	Email
	Mention of online group support system use	#2	1	3/5	Email

[1]ET = Entire team

The value of resource utilization for team 3, based on the sue survey was 4.67. The average score for resource utilization across all teams was 4.69, with the lowest team value of 3.33.

4.1.2.1.2 *Team 5's Resource Utilization*

The evidence related to resource utilization for team 5 is summarized in Table 27.

Table 27

Matrix display: Evidence of resource utilization within team 5 (2008 Study)

Team #	Summarized Material	Contributor(s)	Occurrences	Date of Occurrence(s)	Source
Team 5	Discuss leveraging team member resources	VT[1]		2/6	Email
		#1	1	2/6	Email
		#4		2/6	Email
	A team member was excluded from decision making activities	#2	1	2/28	Email
	Team member not cc'ing the entire team on important emails	#2	1	2/28	Email
	Mention of plan to use an online file sharing program	OSU[2]	1	2/4	Email

[1]VT = All Virginia Tech students participated in the summarized material

[2]OSU = All Oregon State students participated in the summarized material

Team 5 did not appear to be effectively utilizing all team members. One team member was excluded from some of the decision-making activities, and on one occasion, it was noted that one student was not been including the entire team in important emails. On a positive note the team did, early in the project, make some attempts (all on one day) to try and leverage the different skills and knowledge within the team. The average value of team 3's resource utilization on the survey was 3.33. This was the lowest of all the teams in the 2008 study.

4.1.2.1.3 *Resource Utilization for team 8 and 9*

The evidence related to resource utilization for teams 8 and 9 are summarized in Table 28.

Table 28

Matrix display: Evidence related to resource utilization within teams 8 and 9 (2008 Study)

Team #	Summarized Material	Contributor(s)	Occurrences	Date of Occurrence(s)	Source
Team 8	Team member finds online collaboration tool for team	#5	1	2/9	Facebook
	Discuss leveraging team member resources	ET[1] OSU[2] #1	3 1 1	M1[3], M2(x2)[4] M4[5] M4[5]	MSN Messenger
Team 9	Action item assigned to all team members	ET[1]	4	2/8, 2/15, 2/22, 2/29	Meeting Notes

[1]ET = Entire team participated in the summarized material

[2]OSU = All Oregon State students participated in the summarized material

[3]M1 = Occurred during the team's first meeting

[4]M2 = Occurred during the team's second meeting

[5]M4 = Occurred during the team's fourth meeting

Evidence related to the resource utilization of teams 8 and 9 was fairly limited. However, it is noteworthy to mention that both team 8 and 9 scored above average on resource utilization. The average score for both teams was 4.87. The average team value for the entire set of teams was 4.69, with the highest value equal to 5.42.

On five separate occasions discussions were held by members of team 8 about the possibility of leveraging team member resources. Three of the times the entire team participated in the discussion, and one of the times more than half of the team (i.e. all of the OSU students) participated in the discussion. The only evidence gathered from the qualitative data for team 9 is that in all of their meetings, action items were assigned to

each team member, indicating that the team held discussions to determine how to best utilize their team's talents.

4.1.2.2 *Shared Mental Models*

In this section the evidence related to the establishment of shared mental models for teams 3, 5, 8, and 9 is compared and contrasted based on the quantitative data collected.

4.1.2.2.1 *The establishment of Shared Mental Models in Team 3*

Table 29 presents the evidence of team 3's development and establishment of shared mental models. From the table it appears that team 3 laid the groundwork for the team to establish high levels of shared ownership. Early in the project a team member addressed the need to define team roles. When a problem arose a team member addressed the problem within the team and spent time clarifying team member roles and addressing misunderstandings. Twice, reminders were sent out about upcoming meetings. On five occasions, attempts were made to keep the entire team up to date and informed, and on two occasions (before the charter document and the final project deliverable were due) people sent out messages to clarify possible knowledge discrepancies across the team. However, it is notable that of the 15 pieces of evidence collected, nine were from one individual on the team (contributor #3).

The shared mental models survey value for team 3 was 4.5. The average team score was 4.49. Based on the finding that over half of the evidence supporting team 3's establishment of shared mental models came from only one individual, team 3's average shared mental modes value seems reasonable. Shared mental models develop as a result of all the members of in a team, and although one team member can help to develop the shared mental models, one person alone cannot decide whether the team overall will choose to adopt those models.

Table 29

Matrix display: Evidence of shared mental models within the team 3 (2008 Study)

Team #	Summarized Material	Contributor(s)	Occurrences	Date of Occurrence(s)	Source
Team 3	Address a team problem, then reclarify roles	#3	1	2/22	Email
	Constructively address team inactivity	#3	1	2/28	Email
	Sent reminder of upcoming meetings	#3	1	3/7	Email
		#4		2/20	
	End of project: meeting agenda use mentioned	#3	2	3/7, 3/11	Email
	Clarify a possible knowledge discrepancy	#3	1	3/7	Email
		#5		2/13	Email
	Early Project: address need to define roles	#2	2	2/11, 2/12	Email
	Explicit attempt to keep everyone informed	#3	3	3/4, 3/12, 3/14	Email
		#5	2	2/13, 2/15	Email

4.1.2.2.2 *The establishment of Shared Mental Models in Team 5*

The evidence related to the development or existence of shared mental models for team 5 is summarized in Table 30. From the evidence in Table 30 team 5 appeared to have trouble establishing shared mental models. Two days prior to the deadline of the team's first deliverable the team had yet to come to a consensus on the organization the team was going to use in the project. On 2/28 multiple events transpired. One student complained about the team to one of the professors. Next, three separate messages were sent out from the professor, trying to resolve the issues. It took five more messages from the OSU professor and the VT professor (four from OSU's professor and one from VT's professor) to mediate and resolve the problems. Additionally on 2/28 contributor #2 sent

out an email containing important team information and did not forward the message to everyone on the team.

Consistent with the data team 3 had a low average value (3.53) on the shared mental model survey construct. This was the lowest average team value on this construct across all teams.

Table 30

Matrix display: Evidence of shared mental models within the team 5 (2008 Study)

Team #	Summarized Material	Contributor(s)	Occurrences	Date of Occurrence(s)	Source
Team 5	Conflict resolution	OSU Prof	3	2/28(x3)	Email
	Two days before the deadline no project organization is selected	OSU[1]	1	2/13	Email
	Team cohesion problems.... complaint to professor	OSU Prof	1	2/28	Email
	Professor steps in and mediates	OSU Prof	4	2/28(x2), 2/29(x2)	Email
		VT Prof	1	2/28	Email
	Entire team not cc'ed in important emails	#2	1	2/28	Email

[1]OSU = All Oregon State students participated in the summarized material

4.1.2.2.3 *The establishment of Shared Mental Models in teams 8 and team 9*

The evidence related to the development or existence of shared mental models in teams 8 and 9 is summarized in Table 31. From the data in Table 31 team 8 appeared to be engaged in many activities which could help develop shared mental models. However it is notable that no event from Table 31 ever happened twice. Early on the team tried to

keep everybody up-to-data. Also, one of the team members developed a collaboration tool for team. In the first meeting, a new strategy for the collaboration tool previously described was developed. Before the meeting closed, the team discussed and made plans to have all team members email each other their completed work prior to the next team meeting. In the second meeting the team discussed the work that had been completed and made plans for the future. The team also spent time verifying that both OSU and VT were being evaluated the same, and attempts were made to refocus and energize the team. Towards the end of the project, in one important email, a request was made for team members to respond with a confirmation that the important email had been received.

Table 31

Matrix display: Evidence of shared mental models within teams 8 and 9 (2008 Study)

Team #	Summarized Material	Contributor(s)	Occurrences	Date of Occurrence(s)	Source
	Creation of online collaboration tool	#5	1	2/9	Facebook
	Message bringing team up to date	#3	1	2/6	Email
	Request for confirmation of important email	?[3] & #6	1	3/4	Email
	Online collaboration tool ends up not optimal... new strategy created	ET[1]	1	M1[4]	MSN Messenger
	send out premeeting material to align team vision	OSU[2] & #1	1	M1[4]	MSN Messenger
	Verify the consistency of OSU & VT assignment	ET[1]	1	M2[5]	MSN Messenger
	Message to refocus and energize the team	OSU[2] & #1	1	M2[5]	MSN Messenger
	Discusses work to be done and plans for future meeting	ET[1]	1	M2[5]	MSN Messenger
Team 9	Meeting agenda	ET[1]	4	2/15, 2/22, 2/29, 3/11	Meeting Agenda
	Team roles defined in meeting minutes	ET[1]	4	2/8, 2/15, 2/22, 2/29	Meeting Notes

[1]ET = Entire team participated in the summarized material

[2]OSU = All Oregon State students participated in the summarized material

[3] ? = The identity of a contributor is unknown

[4]M1 = Occurred during the team's first meeting

[5]M2 = Occurred during the team's second meeting

Team 8's score from the quantitative analysis was 4.64, which was above average (average = 4.49). The evidence in Table 31 does suggest that the team had engaged in activities to develop a higher level of shared mental models. Team 8 was proactive when

it came to important emails and identified possible information discrepancies (i.e. verifying OSU's assignment was the same as VT's). They also put effort into planning ahead and being prepared.

Due to the limited amount of qualitative material team 9 provided, team 9's establishment of shared mental models cannot be clearly established, based on the evidence. Although as shown in Table 31 team 9 consistently planned for meetings and consistently defined each team member's role for the following week (or time period until the next meeting). Both of these actions offered structure to the team's efforts, which literature suggests will positively impact a team's development of shared mental models. Team 9's average value on the survey was 4.88 for shared mental models, which was above average. Based on the level of structure evident in the team's activities, this value for shared mental models was not unexpected.

4.1.2.3 *Team Member Satisfaction*

In this section the evidence related to team member satisfaction for teams 3, 5, 8, and 9 are compared and contrasted with the survey results.

4.1.2.3.1 *Team 3's Team Member Satisfaction*

The evidence related to team member satisfaction for team 3 is summarized in Table 32. The evidence in Table 32 does not fully clarify the level of satisfaction team members experienced by members of team 3. There was some evidence that team members were enjoying the virtual team experience. Halfway through the project, a positive comment was made about the quality of the team's work. Towards the end of the project, one of the OSU team members mentioned structuring a upcoming meeting so the VT students would not have to "suffer" through another evening meeting (due to time zone differences). The team planned a morning meeting to help balance the suffering. Also at the end of the project a comment "it was good working with you" was noted. Multiple

messages were sent all of which closed in a appositive tone. Approximately 90% of the comments came from a single team member so it is not possible to attribute these feelings to all team members. The value for team 3's team member satisfaction was 4.5, which was below the overall team average of 4.96.

Table 32

Matrix display: Evidence of team member satisfaction within team 3 (2008 Study)

Team #	Summarized Material	Contributor(s)	Occurrences	Date of Occurrence(s)	Source
Team 3	Positive comment regarding work quality	#5	1	2/21	Email
	Messages that end by emphasizing a positive tone	#3	14	2/5, 2/7, 2/11, 2/15(x2), 2/22, 2/28, 3/4, 3/6, 3/7, 3/10, 3/11(x2), 3/12	Email
		#4	1	#4= 2/20	Email
		#5	1	#5= 2/15	Email
	Rotation of meeting times so "everyone suffers equally"	#3	1	3/11	Email
	Statement: It was good working with you	#7	1	3/14	Email

4.1.2.3.2 *Team 5's Team Member Satisfaction*

The evidence related to the level of team member satisfaction achieved by team 5 is summarized in Table 33. The evidence from Table 33 indicates that team 5 showed a lot of motivation and enthusiasm early on in the project. In the first two weeks, on four occasions, comments were made displaying excitement for the educational experience. All of the OSU students from team 5 expressed a desire to finish the project before VT's spring started (meaning that the team would finish the project one week before it was

due). Twice, team members showed motivational enthusiasm towards the project. However on 2/28 the pattern of evidence changes, on the 28th, one student made two complained to one of the instructors about the team. After the complaint both of the professors had to step in and mediate the situation. After these interventions, the team ended four of the subsequent messages in a positive tone. Team 5's average team member satisfaction values were 4.33, below the overall team average value of 4.96

Table 33

Matrix display: Evidence of team member satisfaction within team 5 (2008 Study)

Team #	Summarized Material	Contributor(s)	Occurrences	Date of Occurrence(s)	Source
Team 5	Showing excitement for educational experience	#6	1	2/6	Email
		OSU[1]	2	2/4	Email
		VT[2]	1	2/6	Email
	OSU wants to finish before VT's spring break	OSU[1]	1	2/4	Email
	Student complains to teacher about the team	#2	2	2/28(x2)	Email
	Display of early project. motivational enthusiasm	#4	1	2/6	Email
		OSU[1]		2/4	Email
	After intervention: messages w/positive tone	#2	2	3/4, 3/8	Email
		#3	1	3/4	Email
		#6	1	3/4	Email

[1]OSU = All Oregon State students participated in the summarized material

[2]VT = All Virginia Tech students participated in the summarized material

4.1.2.3.3 *Team 8 and Team 9's Team Member Satisfaction*

The evidence related to the level of team member satisfaction achieved by team 8 and team 9 is summarized in Table 34. It appeared that team 8 put in the ground work to achieve have high levels of team member satisfaction. Early on in the project, the team

indicated plans to finish the project before the VT students started spring break. In the first meeting a team member showed excitement for the educational experience of the virtual team, and in the second meeting the team made positive comments regarding the team's progress, and towards the end of the project when one of the team members sent a late communication, it was followed by a display of commitment to the team. Also throughout the project, on five occasions, messages were ended on a positive note.

Table 34

Matrix display: Evidence of team member satisfaction within teams 8 and 9 (2008 Study)

Team #	Summarized Material	Contributor(s)	Occurrences	Date of Occurrence(s)	Source
Team 8	Ending Message with a positive tone	#1	1	3/10	Email
		#2	2	2/19, 3/11	Facebook & Email
		#3	1	2/6	Email
		ET[1]	1	M1[3]	MSN Messenger
	A want to finish before VT's spring break	#3		2/8	Email
		OSU[2] & #1	1	M2[4]	MSN Messenger
		ET[1]		M1[3]	MSN Messenger
	Late communication response followed by a display of commitment to team	#2	1	3/6	Email
	Showing excitement for educational experience	#2	1	M1[3]	MSN Messenger
	Positive comment regarding the teams progress	ET[1]	1	M2[4]	MSN Messenger
Team 9	Professor complemented team's work	ET[1]	1	2/22	Meeting Notes

[1]ET = Entire team participated in the summarized material

[2]OSU = All Oregon State students participated in the summarized material

[3]M1 = Occurred during the team's first meeting

[4]M2 = Occurred during the team's second meeting

Surprisingly team 8's team member satisfaction score was relatively low in comparison to the other teams. Team 8's average team member satisfaction was 4.67. The overall average value for all the teams was 4.96.

The evidence for team 9's team member satisfaction could not be clearly established, due to the limited amount of qualitative material that team 9 provided. Team 9 received a complement from one of the professors on the quality of the team's work. Team 9's average satisfaction value was 5.33, which was above the overall average team member satisfaction value (average = 4.96).

4.1.2.4 *Team Performance*

The evidence related to team performance achieved by the different teams is summarized in Table 35. Minimal evidence on team performance was identified in the qualitative data provided by the teams.

Table 35
Matrix display: Evidence of team performance within teams 3, 5, 8, and 9 (2008 Study)

Team #	Team Performance	Contributor(s)	Occurrences	Date of Occurrence(s)	Source
Team 3	Positive comment regarding work quality	#1	1	3/10	Email
		#3	2	2/15, 3/14	Email
		#4	1	3/14	Email
		#5	1	2/21	Email
	Team charter submitted late	#3	1	2/22	Email
	Mention of ambition to earn a high grade	#5	1	2/15	Email
Team 5	Professor complemented team's work	VT Prof	1	2/22	Email
	Team given extension to project deadline	OSU Prof	1	3/7	Email
Team 8	Positive comment regarding work quality	#2	1	3/11	Email
		OSU[2] & #1	1	M4[4]	MSN Messenger
	Showing excitement for the educational experience	#2	1	M1[3]	MSN Messenger
Team 9	Professor complemented team's work	ET[1]	1	2/22	Meeting Notes

[1]ET = Entire team participated in the summarized material

[2]OSU = All Oregon State students participated in the summarized material

[3]M1 = Occurred during the team's first meeting

[4]M4 = Occurred during the team's fourth meeting

4.1.3 *Post Hoc Analysis: OSU students vs. VT students*

Before performing the analysis on the demographic data, the assumptions of the one-way ANOVA were checked. First the assumption of normality was assessed. Q-Q plots were created, and upon review of the plots the normality assumption seemed reasonably met. Next the assumption of equal variance was checked. Table 36 presents the results from the Levene's test performed on the data.

Table 36

Levene's test: OSU vs. VT demographic data (2008 Study)

	Levene's Statistic	df1	df2	Sig.
Resource Utilization	2.043	1	48	.159
Shared Mental Models	1.335	1	48	.254
Team Member Satisfaction	2.015	1	48	.162
Subjective Performance	5.191	1	48	.027

Of all the data evaluated in Table 36, only subjective performance was found to violate the assumption of equal variance (p-value <.05). The median test, a nonparametric alternative to an ANOVA, was selected as the model to be used to in place of the ANOVA for the analysis of the subjective performance data. The ANOVA and median test followed. Table 37 presents the results from the ANOVA analysis and Table 38 presents the results from the median tests.

Table 37

ANOVA analysis: OSU vs. VT demographic data (2008 Study)

		Sum of Squares	df	Mean Square	F	Sig.
RU	**Between Groups**	7.695	1	7.695	15.065	.000
	Within Groups	24.517	48	.511		
	Total	32.212	49			
SMM	**Between Groups**	6.388	1	6.388	13.902	.001
	Within Groups	22.057	48	.460		
	Total	28.445	49			
TMS	**Between Groups**	6.592	1	6.592	12.096	.001
	Within Groups	26.158	48	.545		
	Total	32.750	49			

RU = Resource Utilization

SMM = Shared mental model data

TMS = Team member satisfaction

Table 38

Median test: OSU vs. VT demographic data (2008 Study)

	P_Sub
N	50
Median	5.50
Chi-Square	.84
df	1
Asymp. Sig.	.361

P_Sub = Subjective performance

As can be seen from the analysis in Table 37 resource utilization, shared mental models and team member satisfaction were found to be significantly different between students OSU and the students from VT. No significant differences were found in Table 38 between OSU and VT students for subjective performance.

4.2 The 2009 Study

Tables 39 and 40 summarize the descriptive statistics from the 2009 study. A total of 75 students participated in the virtual team projects. Teams were made up of four to five students. Of the 75 who participated in the virtual team projects, 60 chose to complete the survey. The data set for 2009 is divided into two subsets; teams assigned Charter Assignment-A (Table 39) and teams assigned Charter Assignment-B (Table 40).

Table 39

Descriptive statistics: Teams assigned Charter Assignment-A (2009 Study)

		Resource Utilization		Shared Mental Models		Member Satisfaction		Subjective Performance		Objective Performance	
	n	Mean	St Dev	Mean	St Dev	Mean	St Dev	Mean	St Dev	Team Grade	St Dev
Team 1	6	3.88	0.85	4.33	0.76	4.13	1.15	4.33	0.48	4.30	-
Team 3	4	3.19	0.54	3.56	0.89	2.94	0.68	3.50	0.63	4.30	-
Team 5	5	3.35	1.14	3.75	1.41	3.60	1.31	3.85	1.18	4.80	-
Team 7	4	3.63	0.89	4.06	0.68	4.06	0.93	4.88	0.34	4.83	-
Team 9	4	3.75	0.93	3.75	1.06	3.75	1.29	4.20	0.77	4.70	-
Team 11	3	3.25	3.25	3.36	1.91	3.67	1.67	3.58	1.62	4.00	-
Team 13	2	3.75	0.46	4.13	0.83	4.38	0.52	4.50	0.76	4.75	-
Team 15	2	5.00	0.00	4.75	0.35	4.63	0.46	4.88	0.52	4.85	-
All Odd Teams		3.72	0.58	3.96	0.45	3.89	0.52	4.20	0.54	4.57	0.32

Table 40

Descriptive statistics: Teams assigned Charter Assignment-B (2009 Study)

		Resource Utilization		Shared Mental Models		Member Satisfaction		Subjective Performance		Objective Performance	
	n	Mean	St Dev	Mean	St Dev	Mean	St Dev	Mean	St Dev	Team Grade	St Dev
Team 2	3	3.92	0.29	4.17	0.58	3.67	1.23	3.42	0.79	4.53	-
Team 4	3	3.33	1.15	3.25	1.60	2.83	1.47	3.58	0.90	4.50	-
Team 6	2	4.63	0.52	4.63	0.52	4.88	0.35	4.25	0.46	4.45	-
Team 8	4	3.50	0.52	3.94	0.68	3.50	0.63	4.13	0.62	4.55	-
Team 10	2	2.88	0.35	3.43	1.40	2.67	1.21	4.88	0.35	4.95	-
Team 12	3	3.25	0.75	3.50	0.80	3.58	0.79	3.75	0.45	4.90	-
Team 14	4	3.49	0.68	4.19	0.54	3.94	1.00	4.31	0.60	5.00	-
Team 16	2	4.00	0.53	4.00	0.53	4.13	0.83	4.13	0.64	4.85	-
All Even Teams		3.68	0.55	3.89	0.46	3.65	0.70	4.15	0.46	4.72	0.23

4.2.1 *Quantitative Analysis*

In this section the results from the 2009 study's quantitative analysis are discussed.

4.2.1.1 *Survey Reliability and Validity*

To test the survey's reliability, Cronbach's alphas were calculated. The Cronbach's alpha for each construct is presented in Table 41. All alphas were higher than .70, the minimum recommended value to demonstrate internal reliability (Nunnally, 1978).

Table 41

Cronbach's alpha: 2009 survey instrument

Dependent Variable	Number of Survey Items	n	C_α
Resource Utilization	4	62	0.90
Shared Mental Models	4	60	0.87
Team Member Satisfaction	4	61	0.87
Team Member Performance (Subjective)	4	61	0.88
Team Member Performance (Objective)			N/A[1]

[1] Team member performance (objective) was not measured by a survey and therefore it was not appropriate to include it in the analysis

During the creation of the 2009 survey the content validity of the survey was assessed. Upon evaluation, it was determined that the survey items in each construct (used to measure each variable) offered an accurate representation for each variable as defined by this research.

4.2.1.2 *Aggregation of Survey Responses (2009 Study)*

Since the data collected was assessing perceptual measures, it was necessary to collect data at the individual-level (i.e., individuals within teams). Survey items were designed to

reflect group-level attributes, thus the group was used as the referent in all survey items. If the measures work as designed there should be more variation across teams than within teams and there should be a relatively high degree of consensus within the teams. An ANOVA was used to assess whether or not within team variation was lower than between team variation. Table 42 presents the results of this ANOVA.

Table 42

ANOVA: Aggregation of Survey Responses (2009 Study)

		Sum of Squares	df	Mean Square	F	Sig.
RU	**Between Teams**	10.557	15	.704	1.179	.330
	Within Teams	22.096	37	.597		
	Total	32.653	52			
SMM	**Between Teams**	7.815	15	.521	.650	.814
	Within Teams	29.656	37	.802		
	Total	37.472	52			
P_Sub	**Between Teams**	10.849	15	.723	1.448	.177
	Within Teams	18.486	37	.500		
	Total	29.335	52			

RU = Resource Utilization

SMM = Shared mental model data

P_Sub = Subjective performance

Group (or team) level differences were not significantly different in any of the measured variables of the 2009 survey (all p-values $\geq .05$). As a result, it may be difficult to detect team level differences in subsequent analyses. All variables included on the virtual team survey were measured at the individual level. The unit of study, however, is at the team level. An aggregation of individual-level data to produce team-level data should occur only if there is a theoretical rationale for doing so. In this study, all hypotheses were developed at the team level. In addition, all survey items were developed, with the exception of those related to member satisfaction, referring to the team as the unit of

interest, e.g. "My team has a good understanding of each other's task-related knowledge." As a result, aggregation of the data was completed to the team-level for all subsequent analyses. However, for the 2009 data, it should be noted that team-level differences may be difficult to detect due to the amount of variation exhibited between members of each team. This analysis was not done for team member satisfaction because the intent of the survey items measuring team member satisfaction was to capture individual-level satisfaction.

4.2.1.3 *Correlation Analysis*

To assess the presence of relationships between the variables in this study, a correlation analysis was performed. Pearson's correlation coefficient was chosen as the correlation statistic for the analysis. Table 43 presents the results of the correlation analysis between mediating and dependent variables. Again both of the mediating variables (i.e. resource utilization and shared mental models) were found to be highly correlated with each other. However, unlike in the 2008 correlation analysis none of the dependent variables (i.e. subjective performance, objective performance, and team member satisfaction) were found to be correlated with each other at a significant level.

Table 43

Correlation analysis: Mediating and dependent variables (2009 Study)

		RU	SMM	TMS	P_Subj	P_Obj
RU	**Pearson Correlation**	1	.910	.853	.350	-.049
	Sig. (2-tailed)		.000	.000	.184	.858
	N	16	16	16	16	16
SMM	**Pearson Correlation**	.910	1	.859	.481	-.166
	Sig. (2-tailed)	.000		.000	.059	.539
	N	16	16	16	16	16
TMS	**Pearson Correlation**	.853	.859	1	.393	-.146
	Sig. (2-tailed)	.000	.000		.132	.591
	N	16	16	16	16	16
P_Subj	**Pearson Correlation**	.350	.481	.393	1	.167
	Sig. (2-tailed)	.184	.059	.132		.537
	N	16	16	16	16	16
P_Obj	**Pearson Correlation**	-.049	-.166	-.146	.167	1
	Sig. (2-tailed)	.858	.539	.591	.537	
	N	16	16	16	16	16

RU = Resource Utilization

SMM = Shared Mental Models

TMS = Team Member Satisfaction

P_Sub = Subjective Performance

P_Obj = Objective Performance

4.2.1.4 *Hypothesis Checking*

In this section the results from each of the research hypotheses are summarized.

4.2.1.4.1 *Hypothesis 1a, 1b, 2, 3 and 4*

Hypothesis 1a, 1b, 2, 3 and 4 are listed below:

H_{1a}: Shared Ownership shares no relationship with Subjective Team Performance

H_{1b}: Shared Ownership shares no relationship with Objective Team Performance

H_2: Shared Ownership shares no relationship with Team Member Satisfaction

H_3: Shared Ownership shares no relationship with Resource Utilization

H_4: Shared Ownership shares no relationship with Shared Mental Models

To test each of these hypotheses a one-way ANOVA was chosen as the most appropriate statistical model for the analyses. Prior to performing the analyses the model's assumptions were checked (i.e. normally distributed data, equal variance between data sets, and independent data). The normality assumption was checked first. This was done by creating Q-Q plots for each of the sample groups of data being tested. Of all the Q-Q plots, 3 of the plots suggested the possibly of non-normal data. Figure 5 displays the three Q-Q plots suspected of containing non non-normal distributed data.

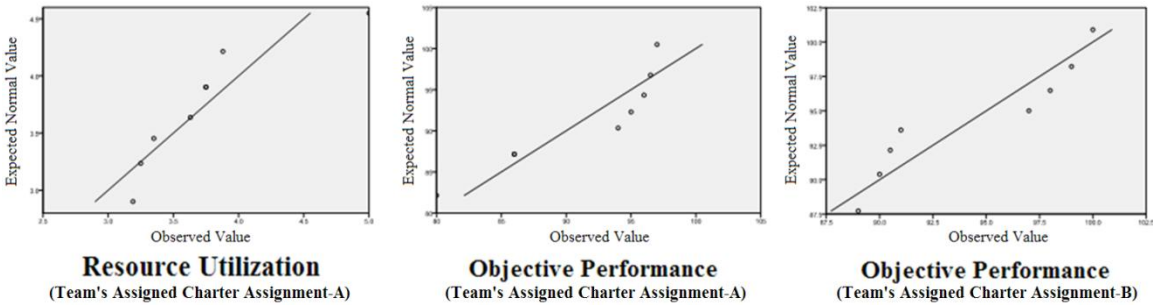

Figure 5: Hypothesis 1a, 1b, 2, 3 and 4: Q-Q plots suspected of containing non-normal data (2009 Study)

As a secondary check the One-Sample Kolmogorov-Smirnov (K-S) test was used to objectively assess the normality of the data presented in Figure 5. The one-sample K-S test offers a quantitative assessment of whether a distribution is not significantly different from a normal distribution. It is an attractive test because the distribution of the K-S test statistic does not depend on the underlying cumulative distribution function, and therefore is a distribution free test. Unlike most statistical tests were non-significant results usually indicate an unfavorable finding, in the K-S test a non-significant result indicates that the null hypothesis is valid and that the distribution being tested does follow a normal distribution. Table 44 presents the results from the K-S analysis.

Table 44

One-Sample Kolmogorov-Smirnov test for normality (2009 Study)

		Resource Utilization	Performance Objective	
		-SO	-SO	+SO
	N	8	8	8
Normal Parameters	**Mean**	3.73	91.31	94.31
	Std. Dev.	0.58	6.40	4.59
Most Extreme Differences	**Absolute**	0.27	0.29	0.27
	Positive	0.27	0.19	0.27
	Negative	-0.18	-0.29	-0.22
Kolmogorov-Smirnov Z		0.76	0.81	0.75
Asymp. Sig. (2-tailed)		0.610	0.522	0.629

-SO; Indicates team data where shared ownership is assumed to be at a low level

+SO; Indicates team data were shared ownership is assumed to be at a high level

As can be seen from Table 44 the normality assumption appears to be reasonably met. Next a Levene's test was run to check for equal variance. Table 45 presents the results from this analysis.

Table 45

Levene's test: Hypothesis 1a, 1b, 2, 3 and 4 (2009 Study)

	Levene's Statistic	df1	df2	Sig.
Resource Utilization	0.161	1	14	0.695
Shared Mental Models	0.017	1	14	0.899
Subjective Performance	0.326	1	14	0.577
Objective Performance	1.776	1	14	0.204
Team Member Satisfaction	0.271	1	14	0.611

As can be seen from Table 45, the variance between teams assumed to have high levels of shared ownership and teams assumed to have low levels of team ownership were not found to be significantly different (all p-values >.05), and therefore the equal variance assumption has not been violated. The independence assumption was also met, all teams in the study were made up of individuals who were only on one team. The ANOVA analysis followed, Table 46 presents the results of the analysis.

Table 46

ANOVA: Hypotheses 1a, 1b, 2, 3 and 4 (2009 Study)

Hypothesis tested		**SS**	**df**	**MS**	**F**	**Sig.**
H_{1a}	Between Odd and Even Teams	0.10	1	0.10	0.40	0.54
	Within All Teams	3.54	14	0.25		
	Total	3.64	15			
H_{1b}	Between Odd and Even Teams	0.13	1	0.13	1.16	0.30
	Within All Teams	1.56	14	0.11		
	Total	1.69	15			
H_2	Between Odd and Even Teams	0.24	1	0.24	0.62	0.44
	Within All Teams	5.42	14	0.39		
	Total	5.66	15			
H_3	Between Odd and Even Teams	0.01	1	0.01	0.02	0.88
	Within All Teams	4.42	14	0.32		
	Total	4.43	15			
H_4	Between Odd and Even Teams	0.02	1	0.02	0.1	0.76
	Within All Teams	2.91	14	0.21		
	Total	2.93	15			

As can be seen from the one-way ANOVA results, summarized in Table 46, the level of shared ownership within a team was not found to be related to any of the dependent variables (all p-values >.05). In Table 47 you can find a summary of the findings for hypotheses 1a, 1b, 2, 3 and 4.

Table 47

Summary of findings for hypotheses 1a, 1b, 2, 3 and 4 (2009 Study)

$H_{\#}$	Hypothesis statement	Finding	P-value
H_{1a}	Shared Ownership shares no relationship with Subjective Team Performance	No significant differences was found between odd and even teams as measured by objective performance	0.54
H_{1b}	Shared Ownership shares no relationship with Objective Team Performance	No significant differences was found between odd and even teams as measured by subjective performance	0.30
H_2	Shared Ownership shares no relationship with Team Member Satisfaction	No significant differences was found between odd and even teams as measured by team member satisfaction	0.44
H_3	Shared Ownership shares no relationship with Resource Utilization	No significant differences was found between odd and even teams as measured by resource utilization	0.88
H_4	Shared Ownership shares no relationship with Shared Mental Models	No significant differences was found between odd and even teams as measured by shared mental models	0.76

4.2.1.4.2 *Hypotheses H_{3a1}-H_{3b} and H_{4a1}-H_{4b}*

No difference in resource utilization, shared mental models, team member satisfaction, or team performance was seen between the teams who completed Charter Assignment-A and the teams who completed Charter Assignment-B. As no differences were observed between these two sets of teams, the hypothesized model of mediated relationships between shared ownership and team performance was not supported by the data collected from this research. As a result, the planned path analyses were no longer relevant. In addition, the data from both sets of teams (those completing Charter Assignment-A and Charter Assignment-B) could be combined to complete the analyses to test for relationships between the mediating and dependent variables. OLS regression was used

for this analysis. Assumptions for an OLS regression include a need for normally distributed errors, non-correlated errors, independence, and linearly related data. The normality and correlation between errors was checked first. Scatter plots were created of the residuals versus fitted values. Figure 6 shows the corresponding residual plots.

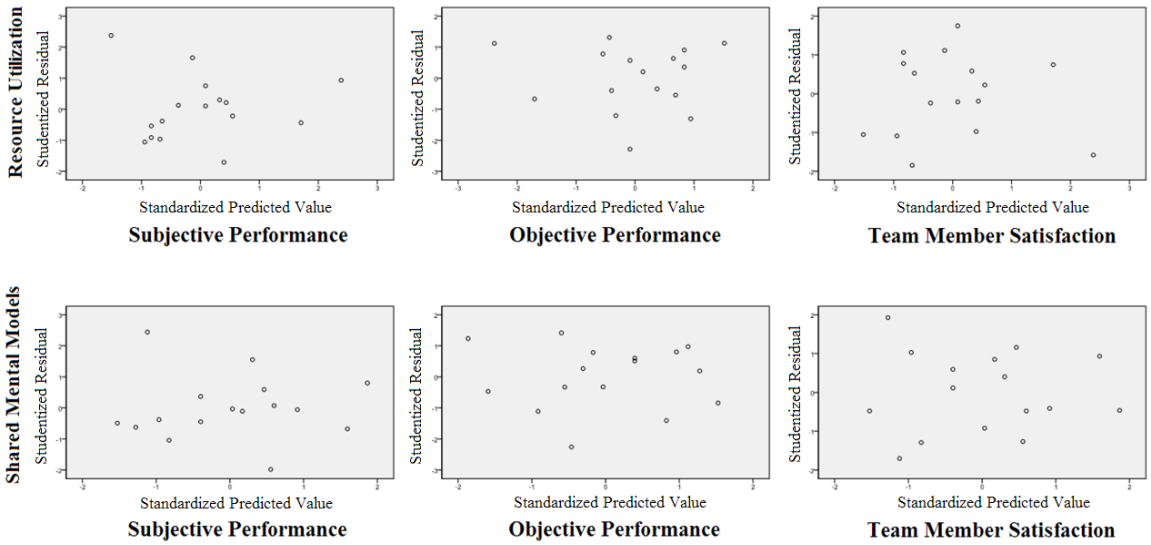

Figure 6: Regression analysis: Plot of residuals versus fitted values (2009 Study)

Upon review of the residual plots in Figure 6, the assumption of normally distributed errors, and the non-correlated errors appears reasonable. The independence assumption was also reasonable. Each virtual team in the study were made up of students who participated on only one team, and each team was held liable only for the work that their own team produced. To check for linearity, scatter plots were created for each of the regression analyses to be performed. Figure 7 displays the scatter plots for both independent variables against all three dependent variables.

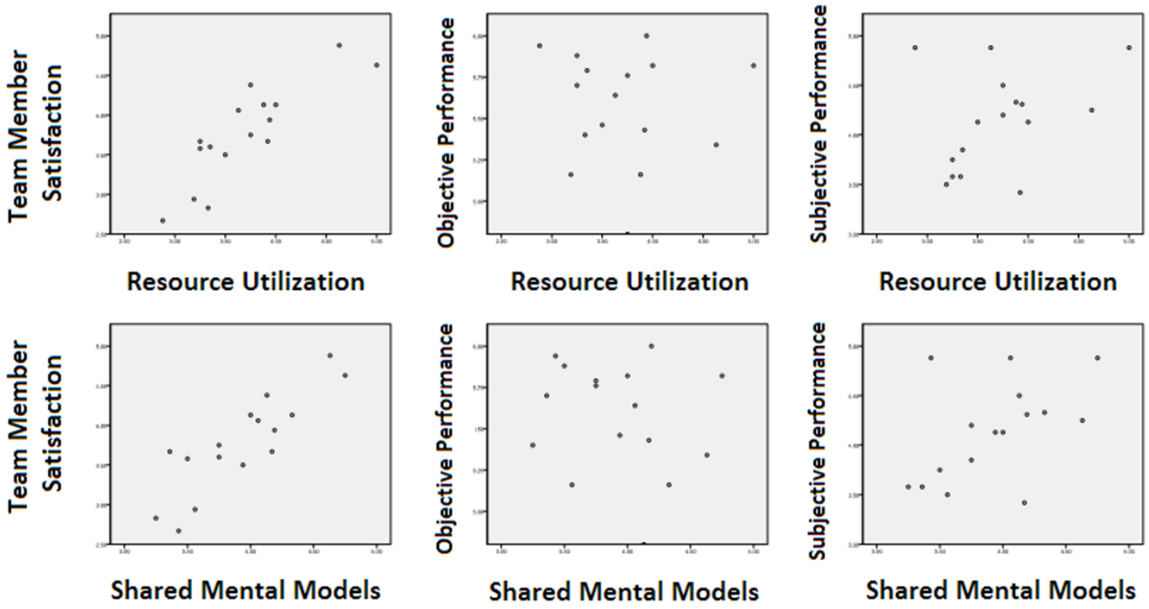

Figure 7: Regression analysis: Scatter plots (2009 Study)

As can be seen from Figure 7, the assumption of linearity does is not unreasonable. OLS regression results are summarized in Table 48.

Table 48

Ordinary Least Squares regression (The 2009 study)

Variable	Subjective Performance				Objective Performance				Team Member Satisfaction			
	β_0	β_1	R^2	P-value	β_0	β_1	R^2	P-value	β_0	β_1	R^2	P-value
Resource Utilization	2.96	.317	.122	.184	4.73	-.025	.002	.858	.205	.963	.727	.000
Shared Mental Models	2.03	.537	.232	.059	5.05	-.105	.027	.539	-.909	1.19	.738	.000

Resource utilization and shared mental models were both found to have a significant effect on team member satisfaction. However, neither resource utilization nor shared mental models were able to predict subjective team performance or objective performance at a significant level.

4.2.2 *Qualitative Analysis*

The qualitative analysis performed in the 2009 study was based on the resources that student participants shared with the primary researcher. In the 2009 study only one team (Team 14) shared their documented correspondence from their virtual team's experience. The data collected was in the form of the team emails. Table 49 presents a summarizing table that includes team 14's score for each of the dependent variables, along with the average team score and the highest and lowest team score from the 2009 quantitative analysis.

Table 49

Summary statistics for qualitative analysis: team values (2009 study)

		Resource Utilization	Shared mental Models	Team Member Satisfaction	Subjective Performance	Objective Performance
	Team 14	3.49	4.19	3.94	4.31	5.00[1]
All Teams	**Average**	3.70	3.92	3.77	4.13	4.64[1]
	High	5.00	4.75	4.88	4.88	5.00[1]
	Low	2.88	3.25	2.67	3.42	4.00[1]

Note: All values indicated in the table were measured on a scale between 1-5

[1] Objective Performance was originally measured on a 100 point scale but for consistency and readability the values were scaled down to be out of 6 points, consistent with all other variables displayed in the table

4.2.2.1 *Resource Utilization*

The pieces of evidence that indicate team 14's resource utilization is summarized in Table 50. The evidence to support team 14's development of resource utilization is not strongly supported in Table 50. Of all of the pieces of evidence found in Table 50, no piece of evidence occurred after the due date of the team's second deliverable (due on 2/18). In the first week of the project, on four occasions within a four day period, the team discussed leveraging team resources, and on one occasion a team member asked for everyone in the team to share an idea in a brainstorming session. In the second week the

evidence related to resource utilization within the team was the development of collaboration tools that the team could use (i.e. Google calendars and a wiki website).

Table 50

Matrix display: Evidence of resource utilization in team 14 (2009 study)

	Summarized Material	Contributor(s)	Occurrences/Contributor	Date of Occurrence(s)	Source
Team 14	Everyone was asked to share an idea	#4	1	2/3	Email
	Discuss leveraging team member resources	#2	#2= 1	#2= 2/5	Email
		#4	#4= 2	#4= 2/3, 2/5	Email
		#5	#5= 1	#5= 2/6	Email
	Creation of availability schedule in Google colanders	#4	1	2/10	Email
	Google calendar =not optimal, created new availability calendars in excel	#4	1	2/13	Email
	Mention possible use of recently found free group support software	#4	1	2/16	Email
	Development of team wiki website	#3	1	2/18	Email

As to be expected team 14's resource utilization score was below average. Team 14 scored a value of 3.49, with the average team score being 3.70.

4.2.2.2 *Shared Mental Models*

The pieces of evidence that indicated team 14's establishment of shared mental models is summarized in Table 51. As indicated in Table 51, team 14 appeared to be doing a lot of things which developed shared mental models. Although early in the project there was uncertainty regarding whether a team member had received an email, the rest of the

evidence in the table indicates team 14 was doing a good job to establish shared mental models. Team member availability schedules were created, on one occasion a team member proactively sent out a message to inform and clarify information to a team member believed to be possibly uninformed, twice in a two day period team members addressed and then redefined team communication standards, and on three occasions the team members spent time planning for an upcoming meeting. Also, on four occasions when a team member did not respond to a message in a timely manner, that team member's follow up response included an apology and a statement indicating the team member's dedication and enthusiasm toward the team and to the team's goal of earning a good grade on the project. Team 14's shared mental model score was slightly above the average of all the 2009 study's teams, Team 14's value was 4.19. The overall average value was 3.92.

Table 51

Matrix display: Evidence of shared mental models in team 14 (2009 study)

	Summarized Material	Contributor(s)	Occurrences/Contributor	Date of Occurrence(s)	Source
Team 14	Uncertainty around if team members have received an email	#4	1	2/5	Email
	Creation of team member availability schedule	#4	2	2/10, 2/13	Email
	Message clarifying possibly uninformed team members	#4	1	2/10	Email
	Apology for late communication followed by statement of dedication and team enthusiasm	#1 #3 #5 OSU[1]	1	#1= 2/9 #3= 2/18 #5= 2/15 OSU= 2/20	Email Email Email Email
	Message redefining team communication standards	#1 #4	1	#1= 2/14 #4= 2/13	Email Email
	Planning for an upcoming meeting	#4 #5 OSU[1]	1	#4=2/24 #5= 2/18 OSU= 2/15	Email

[1]OSU = All Oregon State students participated in the summarized material

4.2.2.3 *Team Member Satisfaction*

The pieces of evidence that indicated team 14's team member satisfaction is summarized in Table 52. As indicated from the evidence in Table 52, team 14 did not seem to develop exceptionally high or exceptionally low levels of team member satisfaction. On four occasions team members sent late responses to team member messages and on one occasion one of the team members indicated to the team that they did not plan to start working on a project deliverable until the last minute. On a positive note, on four

occasions by two different team members messages were sent to either individual team members or the team as a whole, thanking them for one reason or another. Also, early on a message was sent from one of the team members indicating that team member's excitement to be working in team 14, and after the team completed their first team meeting, one of the individuals sent a message stating that the "first meeting had been a success."

As can be reasonably expected team 14 scored a value that was relatively close to the overall average score for all the teams. Team 14's score was 3.94, and the average team score was 3.77 (with the highest team score equal to 4.88, and the lowest score equal to 2.67).

Table 52

Matrix display: Evidence of team member satisfaction in team 14 (2009 study)

	Summarized Material	Contributor(s)	Occurrences/Contributor	Date of Occurrence(s)	Source
Team 14	Messages that end by emphasizing a positive tone	#3	#3= 1	#3= 2/18	Email
		#4	#4= 6	#4= 2/5, 2/9, 2/10(x2), 2/13, 3/1	Email
		#5	#5= 1	#5= 2/6	Email
	Message that show excitement to work with team mates	#4	1	2/5	Email
	Apology for late communication followed by statement of dedication and team enthusiasm	#1	1	#1= 2/9	Email
		#3		#3= 2/18	Email
		#5		#5= 2/15	Email
		OSU[1]		OSU= 2/20	Email
	Statement "first meeting was a success"	#1	1	2/10	Email
	Communication of individual's plan to not start work on a work product deliverable until the last minute	#5	1	2/14	Email Email
	A message thanking a team member or the team as a whole	#2	2	#2= 2/14, 2/18	
		#4		#4= 2/15, 2/22	Email Email

[1]OSU = All Oregon State students participated in the summarized material

4.2.2.4 *Team Performance*

The pieces of evidence which indicate the level of team performance achieved in team 14 are summarized in Table 53. However, the evidence shown in Table 53 does not offer substantial enough evidence to justify further analysis. Instead the author points the

reader to the objective performance values (see Tables 39 and 40), which indicate the actual grades each team received on their virtual team projects.

Table 53

Matrix display: Evidence of team performance within the team 14 (2009 Study)

	Summarized Material	Contributor(s)	Occurrences/Contributor	Date of Occurrence(s)	Source
Team 14	Statement "1st meeting was a success"	#1	1	2/10	Email

4.2.3 *Post Hoc Analyses (2009 Study)*

In this section the demographic data from students completing the 2009 survey were analyzed. A one-way ANOVA was chosen as the most appropriate statistical model for evaluating the differences between survey values among the different demographic groups. Table 54 presents the summary statistics for all of the demographic data.

Table 54

Summary Statistics for the demographic data (2009 study)

		Resource Utilization		Shared Mental Models		Subjective Performance		Member Satisfaction	
	n	Mean	St Dev	Mean	St Dev	Mean	St Dev	Mean	St Dev
Males	44	3.60	0.96	4.11	0.89	3.85	1.03	3.69	1.13
Females	14	3.41	1.06	4.11	0.93	3.79	1.30	3.68	1.40
Undergraduate Students	26	3.35	0.98	4.11	0.91	3.63	1.24	3.56	1.24
Graduate Students	32	3.72	0.96	4.11	0.89	4.00	0.93	3.79	1.15
English as 1st Language	40	3.54	1.00	4.06	0.92	3.79	1.16	3.63	1.23
English is NOT 1st Language	18	3.58	0.96	4.21	0.84	3.93	0.95	3.82	1.12
Has experience with VTs[1]	15	3.54	0.87	4.04	0.96	3.82	0.93	3.50	1.14
Has NO experience with VTs[1]	42	3.59	1.02	4.13	0.87	3.88	1.14	3.78	1.20

[1]VTs = Virtual Teams

4.2.3.1 *Males vs. Females*

Before performing the analysis on the male-female demographic data, the assumptions of the one-way ANOVA were assessed. First the assumption of equal variance was checked. Table 55 presents the results from the Levene's test.

Table 55

Levene's test: Demographic gender data (2009 Study)

	Levene's Statistic	df1	df2	Sig.
Resource Utilization	1.509	1	56	.224
Shared Mental Models	.795	1	56	.377
Subjective Performance	2.866	1	56	.096
Team Member Satisfaction	1.109	1	56	.297

As can be seen from the table, the assumption of equal variance is met in each of the comparisons. Next normality was checked. Q-Q plots were created, and upon review of the plots the assumption of normality was reasonable. The independence assumption was also reasonable. Each virtual team in the study was made up of students who participated on only one team, and each team was held liable only for the work that their own team produced. Table 56 presents the ANOVA for the comparison of the gender specific data.

Table 56

ANOVA: Demographic gender data (2009 Study)

		Sum of Squares	df	Mean Square	F	Sig.
RU	**Between Groups**	.367	1	.367	.487	.488
	Within Groups	42.23	56	.754		
	Total	42.595	57			
SMM	**Between Groups**	.000	1	.000	.000	.991
	Within Groups	33.169	56	.592		
	Total	33.170	57			
TMS	**Between Groups**	.047	1	.047	.056	.814
	Within Groups	47.022	56	.840		
	Total	47.069	57			
P_Sub	**Between Groups**	.000	1	.000	.000	.991
	Within Groups	53.849	56	.962		
	Total	53.849	57			

RU = Resource Utilization

SMM = Shared mental model data

TMS = Team member satisfaction

P_Sub = Subjective performance

As can be seen from the analysis in Table 56, gender was not found to have a significant effect on any of the dependent variables.

4.2.3.2 *Graduates vs. Undergraduates*

Before performing the analysis on the graduate-undergraduate demographic data, the assumptions of the one-way ANOVA were assessed. First the assumption of equal variance was checked. Table 57 presents the results from the Levene's test.

Table 57

Levene's test: Graduate-undergraduate demographic data (2009 Study)

	Levene's Statistic	df1	df2	Sig.
Resource Utilization	.110	1	56	.741
Shared Mental Models	.237	1	56	.628
Subjective Performance	3.599	1	56	.063
Team Member Satisfaction	.039	1	56	.845

As can be seen from the table, the assumption of equal variance is met in each of the comparisons. Next normality was checked. Q-Q plots were created, and upon review of the plots the assumption of normality was reasonable. The independence assumption was also reasonable. Each virtual team in the study was made up of students who participated on only one team, and each team was held liable only for the work that their own team produced. Table 58 presents the ANOVA analyses comparing graduate student data versus undergraduate student data.

Table 58

ANOVA: Graduate-undergraduate demographic data (2009 Study)

		Sum of Squares	df	Mean Square	F	Sig.
RU	**Between Groups**	1.991	1	1.991	2.747	.103
	Within Groups	40.603	56	.725		
	Total	42.595	57			
SMM	**Between Groups**	.000	1	.000	.000	.998
	Within Groups	33.170	56	.592		
	Total	33.170	57			
TMS	**Between Groups**	2.102	1	2.102	2.618	.111
	Within Groups	44.967	56	.803		
	Total	47.069	57			
P_Sub	**Between Groups**	.833	1	.833	.880	.352
	Within Groups	53.016	56	.947		
	Total	53.849	57			

RU = Resource Utilization

SMM = Shared mental model data

TMS = Team member satisfaction

P_Sub = Subjective performance

As can be seen from the analysis in Table 58, differences between graduate students and undergraduate students were not found to have a significant effect on any of the dependent variables.

4.2.3.3 *English as 1st language*

Before performing the analysis on the English as 1st language demographic data, the assumptions of the one-way ANOVA were assessed. First the assumption of equal variance was checked. Table 59 presents the results from the Levene's test.

Table 59

Levene's test: English as 1st language demographic data (2009 Study)

	Levene's Statistic	df1	df2	Sig.
Resource Utilization	.048	1	56	.828
Shared Mental Models	.019	1	56	.890
Team member Satisfaction	.641	1	56	.427
Subjective Performance	.101	1	56	.751

As can be seen from the table, the assumption of equal variance is met in each of the comparisons. Next normality was checked. Q-Q plots were created, and upon review of the plots the assumption of normality was reasonable. The independence assumption was also reasonable. Each virtual team in the study was made up of students who participated on only one team, and each team was held liable only for the work that their own team produced. Table 60 presents the ANOVA analyses comparing the English as 1st language demographic data.

Table 60

ANOVA: English as 1st language demographic data (2009 Study)

		Sum of Squares	df	Mean Square	F	Sig.
RU	**Between Groups**	.026	1	.026	.034	.854
	Within Groups	42.569	56	.760		
	Total	42.595	57			
SMM	**Between Groups**	.281	1	.281	.479	.492
	Within Groups	32.889	56	.587		
	Total	33.170	57			
TMS	**Between Groups**	.232	1	.232	.278	.600
	Within Groups	46.837	56	.836		
	Total	47.069	57			
P_Sub	**Between Groups**	.500	1	.500	.525	.472
	Within Groups	53.349	56	.953		
	Total	53.849	57			

RU = Resource Utilization

SMM = Shared mental model data

TMS = Team member satisfaction

P_Sub = Subjective performance

As can be seen from the analysis in Table X, student's language skills were not found to have a significant effect on any of the dependent variables.

4.2.3.4 *Past experience with virtual teams*

Before performing the analysis on the past experience with virtual teams demographic data, the assumptions of the one-way ANOVA were assessed. First the assumption of equal variance was checked. Table 61 presents the results from the Levene's test.

Table 61

Levene's test: Past experience with virtual teams demographic data (2009 Study)

	Levene's Statistic	df1	df2	Sig.
Resource Utilization	1.037	1	55	.313
Shared Mental Models	1.035	1	55	.313
Team member Satisfaction	1.377	1	55	.246
Subjective Performance	.249	1	55	.620

As can be seen from the table, the assumption of equal variance is met in each of the comparisons. Next normality was checked. Q-Q plots were created, and upon review of the plots the assumption of normality was reasonable. The independence assumption was also reasonable. Each virtual team in the study was made up of students who participated on only one team, and each team was held liable only for the work that their own team produced. Table 62 presents the ANOVA for the comparison of the past experience with virtual teams demographic data.

Table 62

ANOVA: Past experience with virtual teams demographic data (2009 Study)

		Sum of Squares	df	Mean Square	F	Sig.
RU	**Between Groups**	.121	1	.121	.158	.693
	Within Groups	42.269	55	.769		
	Total	42.390	56			
SMM	**Between Groups**	.135	1	.135	.227	.636
	Within Groups	32.617	55	.593		
	Total	32.752	56			
TMS	**Between Groups**	.237	1	.237	.281	.598
	Within Groups	46.384	55	.843		
	Total	46.621	56			
P_Sub	**Between Groups**	1.544	1	1.544	1.627	.207
	Within Groups	52.201	55	.949		
	Total	53.746	56			

As can be seen from the analysis in Table 62, previous experience on a virtual team was not found to have a significant effect on any of the dependent variables.

4.2.3.5 *OSU students versus VT students*

Before performing the analysis on the OSU students versus VT student demographic data, the assumptions of the one-way ANOVA were assessed. First the assumption of equal variance was checked. Table 63 presents the results from the Levene's test.

Table 63

Levene's test: OSU vs. VT demographic data (2009 Study)

	Levene's Statistic	df1	df2	Sig.
Resource Utilization	.010	1	58	.922
Shared Mental Models	.172	1	58	.680
Team member Satisfaction	2.190	1	58	.144
Subjective Performance	.071	1	58	.791

As can be seen from the table, the assumption of equal variance is met in each of the comparisons. Next normality was checked. Q-Q plots were created, and upon review of the plots the assumption of normality was reasonable. The independence assumption was also reasonable. Each virtual team in the study was made up of students who participated on only one team, and each team was held liable only for the work that their own team produced. Table 64 presents the ANOVA for the comparison the OSU students versus VT student demographic data.

Table 64

ANOVA: OSU vs. VT demographic data (2009 Study)

		Sum of Squares	df	Mean Square	F	Sig.
RU	**Between Groups**	.019	1	.019	.025	.876
	Within Groups	44.309	58	.764		
	Total	44.328	59			
SMM	**Between Groups**	.004	1	.004	.006	.937
	Within Groups	34.053	58	.587		
	Total	34.057	59			
TMS	**Between Groups**	.188	1	.188	.225	.637
	Within Groups	48.573	58	.837		
	Total	48.761	59			
P_Sub	**Between Groups**	.005	1	.005	.005	.945
	Within Groups	56.448	58	.973		
	Total	56.453	59			

As can seen from the analysis in Table 64, no significant differences were found between the students from OSU and the students from VT (all p-values >.05).

5 Conclusions

In this section the limitations and implications of the research, along with recommendations for future research are presented. Some of the highlights from the findings of chapter 4 include: The results of the attempt to create different levels of shared ownership between teams was inconclusive. The intervention used to create shared ownership either did not create different levels of shared ownership or the treatment did create different levels of shared ownership and there was no effect. The intent of the team charters used in the study was to create different levels of shared ownership based on the differing levels of work required to complete Charter Assignment-A and Charter Assignment-B. It was intended that in completing these different charter assignments, teams would develop different levels and types of coping strategies that would subsequently impact team processes related to virtual team performance. Charter Assignment-A was intended to create lower levels of shared ownership than Charter-Assignment B. Charter Assignment-A required the student teams to evaluate only a small set of team processes and in general require less effort to complete than Charter Assignment-B. It was not until after the research had been completed that it was recognized that the method used to establish different levels of shared ownership was not consistent with the definition of shared ownership developed for the research. Upon further analysis the definition used to define shared ownership was recognized to not adequately reflect the original intent of the author. Based on this an updated definition was created. The updated definition developed is as follows: shared ownership is created when team members are all held equally liable for the quality of a project deliverable, and shared ownership within a team is the level of commitment team members have to the team and to the development of team processes in support of the team's work.

Resource utilization and shared mental models were shown to be highly correlated, and were both found to be related to team member satisfaction. In the 2008 post hoc analysis of OSU students versus VT students, significant differences in resource utilization, shared mental models, and team member satisfaction were found between OSU and VT

students, however in the 2009 study no significant differences were found between the two groups of students. No other significant differences were found in the post hoc analyses of the male-female, graduate-undergraduate, English as 1st language, or past experience with virtual team demographic groups.

Upon review of the qualitative material, there was evidence to suggest that the team values indicated in the quantitative analyses for both the 2008 and the 2009 study were consistent with the quantitatively measured team values. In the 2008 study a total of four teams contributed qualitative material to the research study, and of the four dependent variables there was enough qualitative material to assess the accuracy of the team values for resource utilization, shared mental models, and team member satisfaction. This amounted to a total of 12 opportunities where the quantitatively measured team values could be compared to qualitative data. Of these 12 opportunities, in eight of the comparisons there was sufficient evidence to support the quantitatively measured team values, or at least enough evidence to support the possibility of the team achieving the indicated team value. On two occasions the qualitative material indicated that the team values were likely to be lower than the values from the quantitative analysis (i.e. team 3's resource utilization value and team 9's team member satisfaction value). On two occasions the evidence from the qualitative analysis was unclear as to the level of team member satisfaction achieved by two of the teams (i.e. teams 3 and 9). In the 2009 study only one team out of the 16 teams who participated in the study contributed qualitative material to this research, and of the four dependent variables, again there was only enough qualitative material to assess the accuracy of the team values for resource utilization, shared mental models, and team member satisfaction. In the 2009 study all the team values that were compared to qualitative material, had qualitative material which supported the values indicated in the quantitative analysis.

5.1 Study Limitations

Three explanations were identified that may have led to the inability of the team charters to establish different levels of shared ownership. First the short duration of the virtual team's project might not have allowed for teams to fully develop the team processes addressed in each teams' charter. The next two possible reasons are related to the level of motivation created by the different charter assignments. Each charter assignment only accounted for 10% of the total grade teams received on the project. Third, both charter assignments were worth the same number of points, so while the assignments should have required different levels of effort, the lack of differentiation in the number of points may not have sufficiently motivated the teams assigned Charter Assignment-B to undertake the level of work needed to create substantially different levels of shared owner.

Another limitation of the study stemmed from the amount of quantitative and qualitative data that was collected in both the 2008 and 2009 study. The amount of quantitative data collected was a direct reflection of the total number of teams who participated in the two studies. In the 2008 study only 11 teams participated in the study, and in the 2009 study only 16 teams participated. The amount of qualitative data collected was a product of teams voluntarily sharing their team's correspondence. The amount of data collected was very much dependent on a team's willingness to provide copies of documented correspondence and on the team's record keeping habits. In the 2008 study, five of the 11 teams shared electronic correspondence. In the 2009 study only one of the 16 teams provided copes of electronic correspondence. The teams that did provide correspondence were only able to provide documents where correspondence had been captured. Some additional team-level correspondence that occurred during the virtual team projects but was not captured included phone conversations and face-to-face interactions between co-located team members.

The design of the two studies also limited the types of inferences that can be drawn. The research performed was not a randomized experiment, but rather a series of two field

studies. As such the results from this research can only be used to identify relationships between variables and not establish causal inferences. There were also limitations related to the inferences that could be made about the findings from this research to different populations of virtual teams. In each of the virtual teams in this research, team members from each university were allowed to select their co-located team members. It was not until after all of the OSU students and all of the VT students had preassembled into sub-teams, that the virtual teams were created by randomly assigning each OSU sub-team to a corresponding VT sub-team, and vice versa. Based on this, the findings from this research can only be generalized to populations of virtual teams where the teams are made up of undergraduate and graduate students from two dispersed universities and whose members are allowed to select co-located team members.

5.2 Implications

In this section the implications of the research are discussed.

5.2.1 *Implications to the Body of Knowledge*

It is believed that increasing the levels of shared ownership within a virtual team has the potential to motivate a virtual team to produce high quality work on an individual project deliverable, and as a by product while the team works on the specific deliverable, team members' willingness and interest in developing important team related processes should be elevated. To our knowledge, this study was the first to attempt to examine the influence of shared ownership on virtual team level processes and performance. Results were not conclusive in establishing that a relationship between shared ownership and team processes (i.e. resource utilization, establishment of shared mental models, team member satisfaction, and team performance) exists. The approach used to establish differing levels of shared ownership was a first attempt at creating commitment in a short-duration project for a virtual team. The results are not necessarily an indication that shared ownership has no effect on virtual team processes or performance. Research on shared ownership is still in its infancy stages, and the inconclusive results from this

research emphasize that research is needed to understand if shared ownership is a significant factor in virtual team performance.

5.2.2 *Implications for Practitioners*

Some practical implications can be drawn from the study. The findings from the 2008 and the 2009 regression analyses indicate that both resource utilization and the ability to develop shared mental models are related to team member satisfaction. It was also found that both resource utilization and the development of shared mental models are highly correlated. So to leverage these findings, practitioners need to look to develop these characteristics as a means to improve team performance.

To develop shared mental models within a virtual team, two strategies are recommended in the literature. The first is the use of planning activities to stimulate the development of shared mental models. For example, a team can set goals, share information related to task requirements (e.g., discuss the consequences of errors and discuss pre-prepared information), and clarify each team member's roles and responsibilities. In addition, teams can discuss relevant environmental characteristics and constraints (e.g., how high workload affects performance, how the team will manage this constraint, and how they will deal with unexpected events). They can prioritize tasks, determine what types of information all of the team members will have access to and what types of information are held by only certain members, and expectations, such as how the team will back each other up or self-correct can be discussed (Stout, Cannon-Bowers, Salas, & Milanovich, 1999).

The second method for developing shared mental models is through the administration of training exercises. However, in the reviewed literature few studies have addressed the type of training that should be used to develop shared mental models. What is known is that the training should have two goals. The first is to develop a team member’s ability to

create appropriate expectations of team behaviors. Secondly it should develop a team member's ability to interpret team behaviors.

To maximize resource utilization within a virtual team, five recommendations from the literature are noteworthy. First, information about differing locations of team members should be collected. Next, that information should be made available to the team and regularly be updated. Unexpected behavior and silences can cause resource utilization problems. Any unexpected behaviors or silences within a team should be investigated and explanations for the occurrence should be shared with the team. Also, to ensure that all team members have access to all team related information, exchanges between team subgroups should be reported to the whole group. Finally, feedback lags (i.e. the allocated amount of time a team allows before a follow-up message is required) need to be specified and tracked (Cramton, 2001).

Recommendations were not only made about resource utilization at a team level, but were also made for individuals who want to be perceived as effective knowledge transfer agents. To be an effective knowledge transfer agent, it is suggested that individuals need to fully participate in electronic conversations, as measured by the team's communication volume. Also individuals need to demonstrate collectivist values and be perceived as credible (Sarker, Sarker, Nicholson, & Joshi, 2005).

5.3 Future Work

As a result of this study, many opportunities for future research have been identified. Most notable are the opportunities related to the development and understanding of how to create different levels of shared ownership, and whether or not this will impact virtual team performance. Future research to develop a method that can be used to induce shared ownership on a team is needed. After different levels of shared ownership have been created, additional research will help identify if significant relationships between team processes and shared ownership exist. It was hypothesized in this research that increased levels of shared ownership would drive teams to improve resource utilization and the

development of shared mental models leading to improved team performance and higher team member satisfaction. It is also possible that shared ownership may be related to other team processes. Some examples of other team-level processes that might be positively impacted by higher levels of shared ownership are team communication and conflict management.

Second, it is possible that shared ownership may affect both virtual teams as well as co-located teams. It is not unlikely for a co-located team to experience similar issues with respect to resource utilization and the development of share mental models as a virtual team. Additional research to study the possible implications of shared ownership on traditional, co-located teams could also make a valuable contribution to the body of knowledge and be relevant to both engineers and engineering managers.

Other opportunities for further research include reproducing the findings from the regression analyses and the 2009 demographic analyses. Because the research was conducted in the field, and not in a laboratory, the findings from these analyses cannot be used to demonstrate causation and are only applicable to the populations evaluated in each analysis. All of the regression analyses and the 2009 demographic data analyses could be replicated in an environment that would increase generalizablility to larger populations of virtual teams and/or findings that could be used to make causal inferences. Also, this research was based on virtual teams of students. Although student teams offer a useful testing ground for theory, these findings may not be applicable to virtual teams found in organizational settings. Future research could also extend this research by conducting the research in organizational settings.

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APPENDICES

Appendix A:
Number of times work cited is referenced in the literature (as measured by Google scholar)

Note: N/A[1] = indicates the citation of a book
N/A[2] = indicates the citation of a website
N/A[3] = indicates that Google Scholar was unable to locate the article

Source	# of Citations
(Alavi & Tiwana, 2002)	188
(Bamberger, 2000)	N/A[1]
(Bjorn & Ngwenyama, 2009)	7
(Carlson & Zmud, 1999)	492
(Cascio, 2000)	230
(Cascio & Shurygailo, 2003)	91
(Chidambaram, 1996)	332
(Chudoba et al., 2005)	16
(Cohen & Bacdayan, 1994)	648
(Cook & Brown, 1999)	1237
(Coppola et al., 2004)	100
(Cordery et al., 2009)	0
(Cramton, 2001)	663
(Cummings, 2004)	346
(Daft & Lengel, 1984)	1315
(Dani et al. 2009)	9
(DeSanctis & Monge, 1999)	408
(DeSanctis & Poole, 1994)	1605
(Dirks, 1999)	450
(Dirks & Ferrin, 2001)	450
(Distefano & Maznevski, 2000)	111
(Duarte & Snyder, 1999)	246
(Edwards et al., 2006)	33
(Espinosa et al., 2007)	26
(Fiol & O'Connor, 2005)	88
(Furumo, 2009)	0
(Galivan, 2001)	116
(Graduate Life Center at Donaldson Brown, 2009)	N/A[2]
(Griffith et al., 2003)	240
(Guo et al., 2009)	0

Source	# of Citations
(Hardin et al., 2007)	19
(Hayes, 1992)	N/A[1]
(Hertel et al., 2004)	87
(Hertel et al., 2005)	136
(Hinds & Bailey, 2003)	209
(Hsu & Chou, 2009)	0
(Hutchins, 1991)	401
(Jarvenpaa & Leidner, 1999)	1415
(Jarvenpaa et al., 2004)	121
(Jarvenpaa et al., 1998)	757
(Kanawattanachai & Yoo, 2007)	53
(Kasper-Fuehrer & Ashkanasy, 2001)	120
(Kayworth & Leidner, 2002)	240
(Kayworth & Leidner, 2000)	142
(Kerlinger & Pedhazur, 1973)	N/A[1]
(Kiesler & Sproull, 1992)	512
(Kirkman & Mathieu, 2005)	68
(Kirkman et al., 2002)	132
(Klimoski & Mohammed, 1994)	693
(Leinonen et al., 2005)	38
(Leonard & Sensiper, 1998)	886
(Li, 1975)	N/A[1]
(Lim & Klein, 2006)	44
(Lee-Kelley et al., 2004)	12
(MacDonnell et al., 2009)	0
(Majchrzak et al., 2005)	68
(Malhotra et al., 2007)	38
(Malhotra et al., 2001)	158
(Martins et al., 2004)	224
(Maznevski & Chudoba, 2000)	668

Source	# of Citations
(Meyerson et al., 1996)	786
(Miles & Huberman, 1984)	N/A[1]
(Mohammed & Dumville, 2001)	271
(Montoya et al., 2009)	2
(Montoya-Weiss et al., 2001)	283
(Muchinsky, 1997)	383
(Ngwenyama & Lee, 1997)	437
(Nonaka, 1994)	7169
(Nunnally, 1978)	N/A[1]
(Panteli & Fineman, 2005)	51
(Paul, 2006)	26
(Pauleen & Yoong, 2001)	62
(Peters & Karren, 2009)	3
(Peterson et al., 2000)	58
(Piccoli & Ives, 2003)	112
(Postmes et al., 1998)	326
(Powell et al., 2004)	347
(Purvanova & Joyce, 2009)	2
(Ramsey & Schafer, 2002)	N/A[1]
(Robert et al., 2009)	2
(Rosen et al., 2007)	N/A[3]
(Rouse et al., 1992)	250
(Rutkowski et al., 2007)	11
(Salvendy, 2001)	N/A[1]
(Sarker et al., 2005)	44
(Sarker & Sahay, 2003)	78
(Sivuen & Valo, 2006)	N/A[3]
(Simon, 1991)	1164
(Sims & Gioia, 1986)	N/A[1]
(Sitkin, 1992)	N/A[1]
(Solomon, 1995)	N/A[3]
(Sproull & Kiesler, 1986)	1380
(Stout et al., 1999)	242
(Szulanski, 1996)	2930
(Townsend et al., 1998)	574
(Vlaar et al., 2008)	12
(Walther J. B., 1995)	436
(Walther J. , 1992)	597

Source	# of Citations
(Warkentin et al., 1997)	333
(Warkentin & Beranek, 1999)	107
(Webley & Lea, 1997)	N/A[2]
(Wegner, 1986)	N/A[1]
(Weick & Westley, 1996)	N/A[1]
(Weick K. , 1991)	356
(Weick & Roberts, 1993)	1748
(Wiesenfeld et al., 1999)	220
(Wilson et al., 2006)	70
(Xie et al., 2009)	0
(Zhang et al., 2009)	3
(Zigurs, 2003)	128
(Zigurs & Buckland, 1998)	388

Appendix B:
Factors described as critical to a virtual team or factors explicitly researched in the literature, including relevant references for each factor

Appendix B.1

Factors: Behavior Control – Task Independence

	Alavi & Tiwana (2002)	Bjorn & Ngwenyama (2009)	Carlson & Zmud (1999)	Caroll et al. (2006)	Cascio (2000)	Cascio & Shurygailo (2003)	Chidambaram (1996)	Coppola et al. (2004)	Cordery et al. (2009)	Cramton (2001)	Daft & Lengel (1984)	DeSanctis & Poole (1994)	DeSanctis & Monge (1999)	Dirks & Ferrin (2001)	Distefano & Maznevski (2000)
Behavior Control															
Collaboration		X													
Collaboration Awareness				X											
Common Incentives and Goals															
Communication	X		X			X					X	X	X		X
Communication Standards									X						
Conflict Resolution															
Coordination															
Culture															X
Evaluations and Rewards															
Feelings of Isolation															
Group Composition															
Human Resource Policies															
Leader Delegation															
Leadership Support					X	X			X						X
Motivation															
Mutual Knowledge	X									X					
Personality Traits of Team Members															
Relational Development							X		X						X
Reward Systems															
Role Clarity															X
Shared Mental Models	X	X													
Task Interdependence															

Factors: Behavior Control – Task Independence

	Duarte & Snyder (1999)	Edwards et al. (2006)	Espinosa et al. (2007)	Fiol & O'Connor (2005)	Furumo (2009)	Galivan (2001)	Gillespie & Chaboyer (2009)	Hertel et al. (2004)	Hertel et al. (2005)	Hinds & Bailey (2003)	Hsu & Chou (2009)	Jarvenpaa et al. (1998)	Jarvenpaa & Leidner (1999)	Jarvenpaa et al. (2004)
Behavior Control						X								
Collaboration											X			
Collaboration Awareness														
Common Incentives and Goals								X						
Communication													X	
Communication Standards	X													
Conflict Resolution					X									
Coordination			X											
Culture	X												X	
Evaluations and Rewards														
Feelings of Isolation														
Group Composition														
Human Resource Policies	X													
Leader Delegation														
Leadership Support	X								X					
Motivation									X					
Mutual Knowledge														
Personality Traits of Team Members														
Relational Development											X			
Reward Systems									X					
Role Clarity														
Shared Mental Models		X					X				X			
Task Interdependence								X						

Factors: Behavior Control – Task Independence

	Kanawattanachai & Yoo (2007)	Kasper-Fuehrer & Ashanasy (2001)	Kayworth & Leidner (2000)	Kayworth & Leidner (2002)	Kirkman et al. (2002)	Kirkman et al. (2004)	Leinonen et al. (2005)	MacDonnell et al. (2009)	Majchrzak et al. (2005)	Malhotra et al. (2007)	Martins et al. (2004)	Mohammed & Dumville (2001)	Montoya et al. (2009)	Montoya-Weiss et al. (2001)	Ngwenyama & Lee (1997)
Behavior Control															
Collaboration									X						
Collaboration Awareness							X								
Common Incentives and Goals		X													
Communication		X											X		X
Communication Standards				X											
Conflict Resolution											X			X	
Coordination														X	
Culture			X							X					
Evaluations and Rewards					X										
Feelings of Isolation					X										
Group Composition											X				
Human Resource Policies															
Leader Delegation															
Leadership Support				X						X					
Motivation															
Mutual Knowledge	X														
Personality Traits of Team Members								X							
Relational Development											X				
Reward Systems															
Role Clarity															
Shared Mental Models												X			
Task Interdependence															

Factors: Behavior Control – Task Independence

	Panteli & Fineman (2005)	Paul (2006)	Peters & Karren (2009)	Piccoli & Ives (2003)	Postmes et al. (1998)	Powell etal. (2004)	Purvanova & Bono (2009)	Robert Jr et al. (2009)	Rouse et al. (1992)	Sarker & Sahay (2003)	Solomon (1995)	Stout et al (1999)	Townsend et al. (1998)	Vlaar et al. (2008)
Behavior Control				X									X	
Collaboration		X									X			
Collaboration Awareness														
Common Incentives and Goals											X			
Communication						X				X	X			
Communication Standards											X			
Conflict Resolution														
Coordination						X								
Culture			X			X								
Evaluations and Rewards														
Feelings of Isolation														
Group Composition			X											
Human Resource Policies														
Leader Delegation														
Leadership Support							X							
Motivation														
Mutual Knowledge		X												
Personality Traits of Team Members														
Relational Development						X								
Reward Systems														
Role Clarity														
Shared Mental Models									X					X
Task Interdependence														

Factors: Behavior Control – Task Independence

	Walther (1995)	Warkentin et al. (1997)	Warkentin & Beranek (1999)	Wegner (1987)	Wiesenfeld et al. (1999)	Wilson et al. (2006)	Xie et al. (2009)	Zhang et al. (2009)	Zigurs (2003)	Zigurs (1998)
Behavior Control										
Collaboration										
Collaboration Awareness										
Common Incentives and Goals										
Communication	X	X	X		X					
Communication Standards										X
Conflict Resolution										
Coordination										
Culture										
Evaluations and Rewards										
Feelings of Isolation										
Group Composition										
Human Resource Policies										
Leader Delegation								X		
Leadership Support								X	X	
Motivation								X		
Mutual Knowledge										
Personality Traits of Team Members										
Relational Development	X	X							X	
Reward Systems										
Role Clarity									X	
Shared Mental Models							X			
Task Interdependence										

Appendix B.2

Factors: Task and Team Familiarity – Trust Development

	Alavi & Tiwana (2002)	Bjorn & Ngwenyama (2009)	Carlson & Zmud (1999)	Carol et al. (2006)	Cascio (2000)	Cascio & Shurygailo (2003)	Chidambaram (1996)	Coppola et al. (2004)	Cordery et al. (2009)	Cramton (2001)	Daft & Lengel (1984)	DeSanctis & Poole (1994)	DeSanctis & Monge (1999)	Dirks & Ferrin (2001)	Distefano & Maznevski (2000)
Task and Team Familiarity															
Team Based Rewards															
Team Cohesion															
Team Conflict															
Team Design															
Team Empowerment															
Team Flexibility															
Team Identification															
Team Knowledge, Skills, and Abilities															
Team Meetings						X									
Team Member Silence															
Team Planning															
Team Size															
Team Structure and Norms													X		X
Technology											X		X		
Training					X										
Transactive Memory	X														
Trust Development			X			X		X				X		X	X

Factors: Task and Team Familiarity – Trust Development

	Duarte & Snyder (1999)	Edwards et al. (2006)	Espinosa, Slaughter, Kraut, & Herbsleb (2007)	Fiol & O'Connor (2005)	Furumo (2009)	Galivan (2001)	Gillespie & Chaboyer (2009)	Hertel et al. (2004)	Hertel et al. (2005)	Hinds & Bailey (2003)	Hsu & Chou (2009)	Jarvenpaa et al. (1998)	Jarvenpaa & Leidner (1999)	Jarvenpaa et al. (2004)
Task and Team Familiarity			X											
Team Based Rewards								X						
Team Cohesion									X					
Team Conflict					X					X	X			
Team Design									X					
Team Empowerment														
Team Flexibility														
Team Identification				X					X					
Team Knowledge, Skills, and Abilities		X												
Team Meetings														
Team Member Silence														
Team Planning														
Team Size														
Team Structure and Norms														
Technology	X													
Training	X								X					
Transactive Memory									X					
Trust Development									X			X	X	X

Factors: Task and Team Familiarity – Trust Development

	Kanawattanachai & Yoo (2007)	Kasper-Fuehrer & Ashanasy (2001)	Kayworth & Leidner (2000)	Kayworth & Leidner (2002)	Kirkman et al. (2002)	Kirkman, Rosen, Tesluk, & Gibon (2004)	Leinonen et al. (2005)	MacDonnell, O;Neill, Kline, & Hambley (2009)	Majchrzak, Malhotra, & John (2005)	Malhotra et al. (2007)	Martins et al. (2004)	Mohammed & Dumville (2001)	Montoya et al. (2009)	Montoya-Weiss et al. (2001)	Ngwenyama & Lee (1997)
Task and Team Familiarity															
Team Based Rewards															
Team Cohesion															
Team Conflict															
Team Design															
Team Empowerment						X									
Team Flexibility															
Team Identification															
Team Knowledge, Skills, and Abilities											X				
Team Meetings										X					
Team Member Silence															
Team Planning											X				
Team Size											X				
Team Structure and Norms															
Technology		X							X	X	X				X
Training															
Transactive Memory	X											X			
Trust Development		X								X			X		

Factors: Task and Team Familiarity – Trust Development

	Panteli & Fineman (2005)	Paul (2006)	Peters & Karren (2009)	Piccoli & Ives (2003)	Postmes et al. (1998)	Powell etal. (2004)	Purvanova & Bono (2009)	Robert Jr et al. (2009)	Rouse et al. (1992)	Sarker & Sahay (2003)	Solomon (1995)	Stout et al (1999)	Townsend et al. (1998)	Vlaar et al. (2008)
Task and Team Familiarity														
Team Based Rewards														
Team Cohesion						X							X	
Team Conflict														
Team Design						X							X	
Team Empowerment														
Team Flexibility														
Team Identification					X									
Team Knowledge, Skills, and Abilities						X								
Team Meetings														
Team Member Silence	X													
Team Planning												X		
Team Size														
Team Structure and Norms										X				
Technology						X							X	
Training						X							X	
Transactive Memory														
Trust Development			X			X		X					X	

Factors: Task and Team Familiarity – Trust Development

	Walther (1995)	Warkentin et al. (1997)	Warkentin & Beranek (1999)	Wegner (1987)	Wiesenfeld et al. (1999)	Wilson et al. (2006)	Xie et al. (2009)	Zhang et al. (2009)	Zigurs (2003)	Zigurs (1998)
Task and Team Familiarity										
Team Based Rewards										
Team Cohesion										
Team Conflict										
Team Design										
Team Empowerment										
Team Flexibility								X		
Team Identification					X					
Team Knowledge, Skills, and Abilities										
Team Meetings										
Team Member Silence										
Team Planning										
Team Size										
Team Structure and Norms										
Technology		X							X	X
Training			X							
Transactive Memory				X						
Trust Development						X				

Appendix C
The virtual performance design project assignment and grading rubric used to evaluate completed projects

Appendix C.1
The assignment and grading rubric used to evaluate completed projects from the 2008 Study

ISE 5016 Spring 2008
IE 470 Winter 2008
Virtual Performance Measurement System Design Project

Virtual Performance Measurement System Design Project
Groups of students enrolled in ISE 5016 and IE 470 will design a performance measurement system for any existing organization. Work for the design project will be completed in groups. Each group will submit a single work product, representing the overall efforts of the group.

Conduct Expectations
The Virginia Tech Honor Code and Oregon State University Student Code of Conduct and Academic Honesty Policies are in effect for this project.

Project Group Logistics
This project will be completed in groups of 5 – 6 students. Each project group will be composed of students from both Virginia Tech and Oregon State University. Dr. Godfrey and Dr. Doolen will assign students to a virtual group. All students will be provided with the names and e-mail addresses of their group members.

Target Organizational System Identification
All project groups must conduct at least one group meeting and select a single target organization for the project by 2/15/08. A single e-mail from the group must be sent to both Dr. Doolen (doolen@engr.orst.edu) and Dr. Godfrey (j.godfrey@vt.edu) by 5:00 pm PT on 02/15/08 with the target organization's name and a short paragraph (3 – 5 sentences) about the nature of the organization, e.g. for profit, nonprofit, industrial sector, etc. The e-mail should also briefly describe the rationale for the group's selection, e.g. interest in the sector, organization that has employed group members, etc. The e-mail should include the first and last names of all group members.

Virtual Team Charter Document
Working on a virtual team can be more challenging than working on a team that is co-located. One of the objectives of this project is to provide students at Virginia Tech and Oregon State University an opportunity to complete a relatively complex project in a

virtual environment. Through this experience, students will gain valuable insights into strategies that can be used to successfully navigate a virtual work environment. Some aspects of the measurement system design project have been created to help students avoid some of the common pitfalls faced by virtual teams.

All project groups must create a group charter for the project by 2/22/08. A single e-mail with the group charter must be sent to both Dr. Doolen (doolen@engr.orst.edu) and Dr. Godfrey (j.godfrey@vt.edu) by 5:00 pm PT on 02/22/08. The e-mail should include the first and last names of all group members. The team charter must be two pages or less. A bullet format is appropriate for many of the sections in the team charter document. The charter document must include the following sections (additional sections may also be added):

1. Group Objectives: What organizational system has the group chosen for the design activity? What are the group's objectives? Objectives should define more specifically what the group will accomplish. These may be related to the design project and to group/individual learning. Groups should also discuss academic performance goals, related to their course grades, i.e. be clear about what grade and level of effort each group member is expecting.
2. Target Organization Overview: Provide a brief overview of the organizational system. This description could include an overview of key business processes, products/services, customers, whether part of a higher-level system, etc.
3. Group Processes: What key processes will the group use to manage the project work? For example, how will the group make decisions? How often will the group meet? What technology will the group use for its meetings? How will the group maintain documents?
4. Roles: What tasks need to be performed? Who will be responsible for the tasks? Groups may assign roles such as group leader, documentation coordinator, note taker, etc. Groups may also want to include a Gantt chart mapping out tasks, milestones, and target dates.
5. Principles of Operation: What principles, or ground rules, will the group use to guide decisions and behaviors?

Organizational Performance Measurement System Design Report

Groups will complete the following six steps to design and document the development of a measurement system for the target organization. These steps will be documented in a final project report. A single e-mail with the final report must be sent to both Dr. Doolen (doolen@engr.orst.edu) and Dr. Godfrey (j.godfrey@vt.edu) by 5:00 pm PT on 03/14/08. The e-mail should include the first and last names of all group members. The project report must be fewer than 10 pages. The project report must include the following sections (additional sections may also be added):

1. Need for Measurement. This should be a short paragraph that concisely defines why a performance measurement system will be valuable for this organization. This

section should answer the following questions: Who will use the measurement system (who are you designing it for)? What sort of performance questions will it answer? Are there any specific types of problems the organization is facing that would be helped by the development/use of a performance measurement system?

2. SIPOC diagram: See, for example, http://www.isixsigma.com/library/content/c010429a.asp
3. Mission Statement: Write a brief (1-2 sentence) mission statement for the organization based on your perception of its core focus. If the organization already has a mission statement, describe how and why the mission statement you wrote is similar to and different from the actual mission statement. Include a copy, with citation, of the organization's actual mission statement. If the organization does not have a mission statement that you can access, explain the rationale for the mission statement created by your group.
4. SWOT Analysis: Identify at least one external opportunity and one external threat facing the organization. Identify an internal strength and an internal weakness, which help/hinder the organization in/from achieving its mission. If you are not familiar enough with the organization to identify actual internal strengths and weaknesses, you can identify hypothetical strengths and weaknesses, but indicate that they are hypothetical.
5. Metrics: Identify two appropriate metrics for each of the four balanced score card dimensions Complete the following portions of the Metrics Development Matrix (MDM) for the eight metrics. An MDM template will be posted on Blackboard
   a. Metrics Specification: You may leave the Metric Owner column blank.
   b. Portrayal Design: Complete all three columns.
   c. Data Collection: Complete only the Data Collection Tool(s) and the Data Collection Frequency columns.
   d. You do not need to complete any columns in the Utilization section.
6. Measurement System Audit: Map the eight metrics against the five dimensions of the SIPOC framework (suppliers, inputs, processes, outputs, customers). If there are gaps (i.e., dimensions with no metrics), list at least one potential metric for each uncovered dimension; you do not need to fully define these additional metrics using the MDM. Choose a second framework, for example the Malcolm Baldrige National Quality Award (MBNQA), Sing/Tuttle Model, Neely's Performance Prism framework, Drucker's Eight Key Results Area, etc. to compare your chosen metrics against. Using the revised list of metrics (i.e., the original eight metrics and any additional metrics from the SIPOC comparison), map the metrics against the dimensions of the second framework. List at least one potential metric for each dimension not covered (if any); again, you do not need to fully define these additional metrics using the MDM. If you do not add any additional metrics, describe how the metrics satisfy both the SIPOC and your second chosen framework. Information about the MBNQA can be found at http://www.quality.nist.gov/Business_Criteria.htm and at http://en.wikipedia.org/wiki/Malcolm_Baldrige_National_Quality_Award

Performance Issues

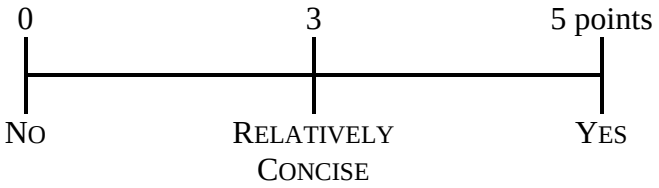
Groups should utilize their principles of operation and the team charter document to manage group performance and behavioral expectations. Miscommunication and misunderstandings are not uncommon in a virtual team environment. Students should use all of the communication technology at your disposal to ensure that all group members are kept in the loop. If teams are unable to resolve conflicts or if there are unresolved issues with individual student participation/contribution, Dr. Doolen and Dr. Godfrey must be notified as soon as possible. Dr. Doolen and Dr. Godfrey will intervene and work with the individual and group to develop a path forward.

Project Evaluation Criteria

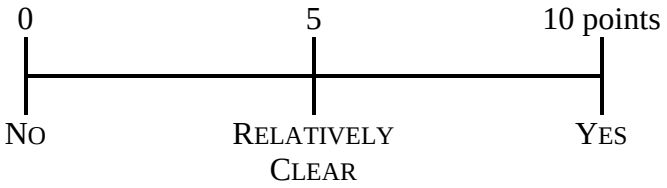
All deliverables will be evaluated by both Dr. Doolen and Dr. Godfrey. Dr Doolen will assign final group grades for students in IE 470. Dr. Godfrey will assign final group grades for students in ISE 5016. The Target System Identification e-mail is worth 5 points. 5 points will be assigned to all groups who submit this e-mail on time. The Team Charter e-mail is worth 10 points. 10 points will be assigned to all groups who submit this assignment via e-mail on time. The final project report is worth 60 points. The grading rubric for the final project report will be posted on the course Blackboard site. All OSU students in a group will receive the SAME grade for all deliverables. Similarly, all VT students in a group will receive the SAME grade for all deliverables.

IE 470 FINAL PROJECT GRADING RUBRIC

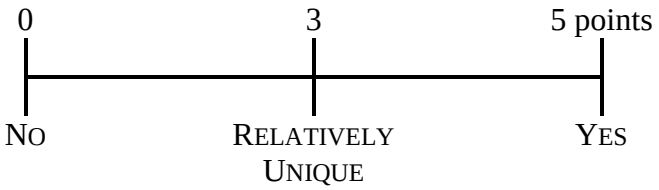
Need for Measurement: (5 points) Concisely defines why a performance measurement system will be valuable for this organization. Specifies who will use the measurement system and the performance issues that it will help the organization address.



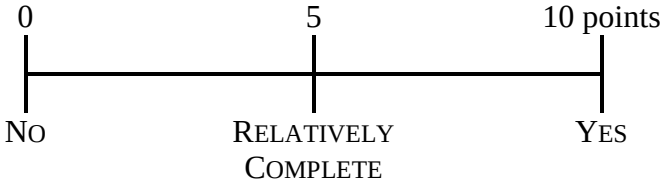
SIPOC Diagram (10 points) SIPOC diagram for the organization is included and all elements clearly defined



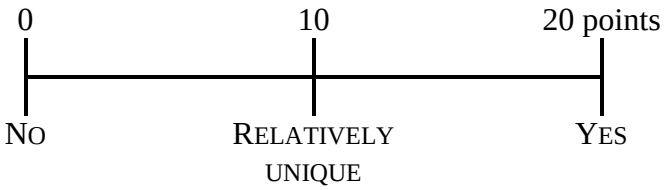
Mission Statement (5 points) Mission is descriptive and unique to the organizational target. The unique value-add of the organization is clearly defined. The mission statement is written concisely. A comparison with the existing mission statement is completed or the rationale for the mission statement is described.



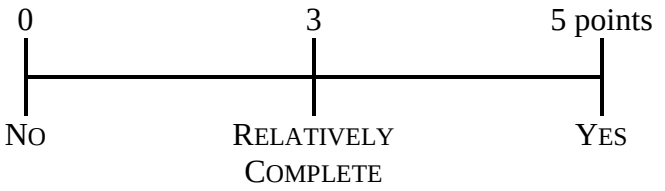
SWOT Analysis (10 points) The strengths, weaknesses, opportunities and threats are specific to the target organization. All SWOT elements have been completed and clearly documented.



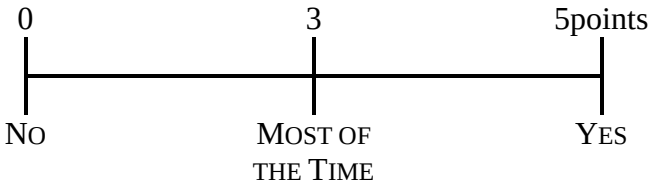
Metrics (20 points) Eight clearly defined metrics have been developed. Metrics are logically connected to the four areas of the balanced score card. Metrics are not redundant. Metrics are clearly relevant to the target organization.



Measurement System Audit (5 points) Metrics are compared with the SIPOC and MBNQA frameworks. Additional metrics are defined for gaps. Coverage of both frameworks is described.



Clear Writing Composition (5 points) The report was easy to read (i.e., flowed logically, used headings/subheadings/exhibits wisely). The report used proper grammar and good spelling, throughout. Appropriate citations were used.



TOTAL SCORE:_____/60

Appendix C.2
The assignment and grading rubric used to evaluate completed projects from the 2009 Study

ISE 5016 Spring 2009
IE 470 & IE 570 Winter 2009
Virtual Performance Measurement System Design Project

Virtual Performance Measurement System Design Project
Groups of students enrolled in ISE 5016 and IE 470/570 will design a performance measurement system for any existing organization. Work for the design project will be completed in groups. Each group will submit a single work product, representing the overall efforts of the group.

Conduct Expectations
The Virginia Tech Honor Code and Oregon State University Student Code of Conduct and Academic Honesty Policies are in effect for this project.

Project Group Logistics
This project will be completed in groups of 4 – 5 students. Each project group will be composed of students from both Virginia Tech and Oregon State University. Dr. Godfrey and Dr. Doolen will assign students to a virtual group. All students will be provided with the names and e-mail addresses of their group members.

Target Organizational System Identification
All project groups must conduct at least one group meeting and select a single target organization for the project. A single e-mail from the group must be sent to both Dr. Doolen (doolen@engr.orst.edu) and Dr. Godfrey (j.godfrey@vt.edu) by 5:00 pm PT on 02/11/09 with the target organization's name and a short paragraph (3 – 5 sentences) about the nature of the organization, e.g. for profit, nonprofit, industrial sector, etc. The e-mail should also briefly describe the rationale for the group's selection, e.g. interest in the sector, organization that has employed group members, etc. The e-mail should include the first and last names of all group members. This deliverable is worth 5 points.

Virtual Team Charter Document
Working on a virtual team can be more challenging than working on a team that is co-located. One of the objectives of this project is to provide students at Virginia Tech and Oregon State University an opportunity to complete a relatively complex project in a virtual environment. Through this experience, students will gain valuable insights into strategies that can be used to successfully navigate a virtual work environment. Some aspects of the measurement system design project have been created to help students avoid some of the common pitfalls faced by virtual teams.

All project groups must create a group charter for the project. A single e-mail with the group charter (as an attachment) must be sent to both Dr. Doolen (doolen@engr.orst.edu) and Dr. Godfrey (j.godfrey@vt.edu) by 5:00 pm PT on 02/18/09. The e-mail should include the first and last names of all group members. The team charter must be two pages or less. A bullet format is appropriate for many of the sections in the team charter document. The charter document must include the following sections (additional sections may also be added):

The format of the charter document will vary based on your assigned team number. Odd numbered teams will use the charter document format specified for odd teams, and even numbered teams will use the charter document format specified for even teams. A grading rubric is available along with the required sections of the team charter.

Organizational Performance Measurement System Design Report

Groups will complete the following six steps to design and document the development of a measurement system for the target organization. These steps will be documented in a final project report. A single e-mail with the final report must be sent to both Dr. Doolen (doolen@engr.orst.edu) and Dr. Godfrey (j.godfrey@vt.edu) by 5:00 pm PT on 03/06/09. The e-mail should include the first and last names of all group members. The project report must be fewer than 10 pages. The project report must include the following sections (additional sections may also be added):

1. Need for Measurement. This should be a short paragraph that concisely defines why a performance measurement system will be valuable for this organization. This section should answer the following questions: Who will use the measurement system (who are you designing it for)? What sort of performance questions will it answer? Are there any specific types of problems the organization is facing that would be helped by the development/use of a performance measurement system?

2. SIPOC diagram: See, for example, http://www.isixsigma.com/library/content/c010429a.asp

3. Mission Statement: Write a brief (1-2 sentence) mission statement for the organization based on your perception of its core focus. If the organization already has a mission statement, describe how and why the mission statement you wrote is similar to and different from the actual mission statement. Include a copy, with citation, of the organization's actual mission statement. If the organization does not have a mission statement that you can access, explain the rationale for the mission statement created by your group.

4. SWOT Analysis: Identify at least one external opportunity and one external threat facing the organization. Identify an internal strength and an internal weakness, which help/hinder the organization in/from achieving its mission. If you are not

familiar enough with the organization to identify actual internal strengths and weaknesses, you can identify hypothetical strengths and weaknesses, but indicate that they are hypothetical.

5. Metrics: Identify two appropriate metrics for each of the four balanced score card dimensions Complete the following portions of the Metrics Development Matrix (MDM) for the eight metrics. An MDM template will be posted on Blackboard
   a. Metrics Specification: You may leave the Metric Owner column blank.
   b. Portrayal Design: Complete all three columns.
   c. Data Collection: Complete only the Data Collection Tool(s) and the Data Collection Frequency columns.
   d. You do not need to complete any columns in the Utilization section.

6. Measurement System Audit: Map the eight metrics against the five dimensions of the SIPOC framework (suppliers, inputs, processes, outputs, customers). If there are gaps (i.e., dimensions with no metrics), list at least one potential metric for each uncovered dimension; you do not need to fully define these additional metrics using the MDM. Choose a second framework, for example the Malcolm Baldrige National Quality Award (MBNQA), Sing/Tuttle Model, Neely's Performance Prism framework, Drucker's Eight Key Results Area, etc. to compare your chosen metrics against. Using the revised list of metrics (i.e., the original eight metrics and any additional metrics from the SIPOC comparison), map the metrics against the dimensions of the second framework. List at least one potential metric for each dimension not covered (if any); again, you do not need to fully define these additional metrics using the MDM. If you do not add any additional metrics, describe how the metrics satisfy both the SIPOC and your second chosen framework. Information about the MBNQA can be found at http://www.quality.nist.gov/Business_Criteria.htm and at http://en.wikipedia.org/wiki/Malcolm_Baldrige_National_Quality_Award

Performance Issues

Groups should utilize their principles of operation and the team charter document to manage group performance and behavioral expectations. Miscommunication and misunderstandings are not uncommon in a virtual team environment. Students should use all of the communication technology at your disposal to ensure that all group members are kept in the loop. If teams are unable to resolve conflicts or if there are unresolved issues with individual student participation/contribution, Dr. Doolen and Dr. Godfrey must be notified as soon as possible. Dr. Doolen and Dr. Godfrey will intervene and work with the individual and group to develop a path forward.

Project Evaluation Criteria

All deliverables will be evaluated by both Dr. Doolen and Dr. Godfrey. Dr Doolen will assign final group grades for students in IE 470 and IE 570. Dr. Godfrey will assign final group grades for students in ISE 5016. The Target System Identification e-mail is

worth 5 points. 5 points will be assigned to all groups who submit this e-mail on time. The Team Charter e-mail is worth 10 points. Teams must complete a charter following the instructions provided based on whether your team number is an odd number or even number. There is a grading rubric for the team charter. The final project report is worth 85 points. The grading rubric for the final project report will be provided for students. All OSU students in a group will receive the SAME grade for all deliverables. Similarly, all VT students in a group will receive the SAME grade for all deliverables.

ISE 5016 and IE 470/570 PERFORMANCE MEASURMENT SYSTEM DESIGN PROJECT: GRADING MEASURES

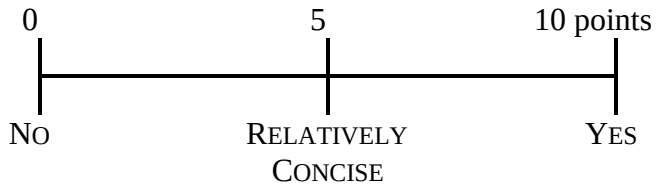
PROJECT INCEPTION

Target System Identification (5 points) Submit e-mail on time identifying target system.

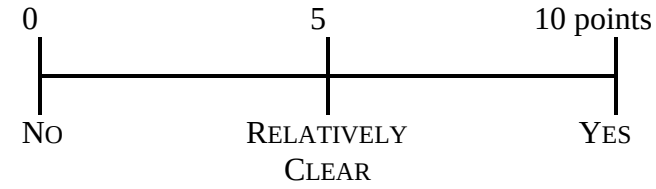
Team Charter (10 points) Submit email on time reporting the team charter.

PROJECT REPORT

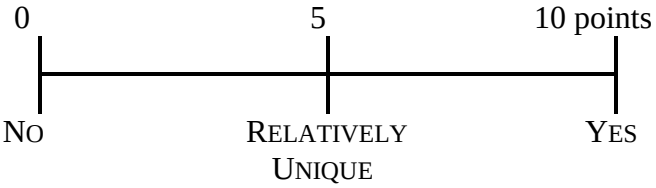
Need for Measurement: (10 points) Concisely defines why a performance measurement system will be valuable for this organization. Specifies who will use the measurement system and the performance issues that it will help the organization address.



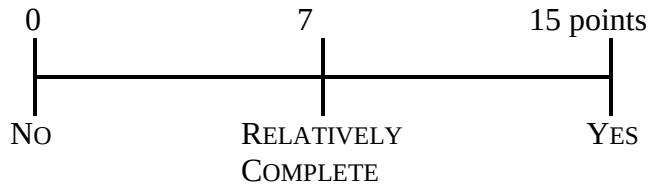
SIPOC Diagram (10 points) SIPOC diagram for the organization is included and all elements clearly defined



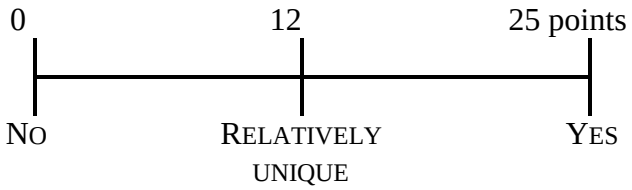
Mission Statement (10 points) Mission is descriptive and unique to the organizational target. The unique value-add of the organization is clearly defined. The mission statement is written concisely. A comparison with the existing mission statement is completed or the rationale for the mission statement is described.



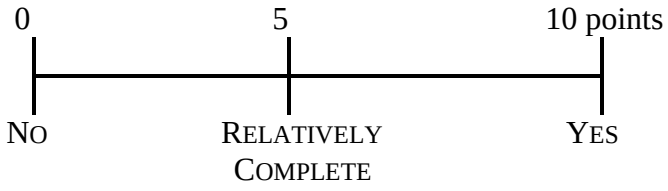
SWOT Analysis (15 points) The strengths, weaknesses, opportunities and threats are specific to the target organization. All SWOT elements have been completed and clearly documented.



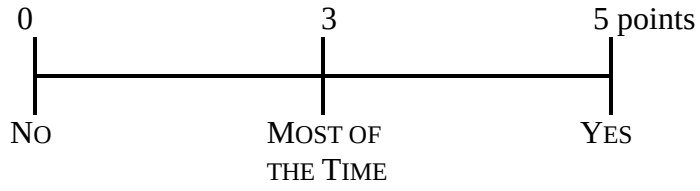
Metrics (25 points) Eight clearly defined metrics have been developed. Metrics are logically connected to the four areas of the balanced score card. Metrics are not redundant. Metrics are clearly relevant to the target organization.



Measurement System Audit (10 points) Metrics are compared with the SIPOC and MBNQA frameworks. Additional metrics are defined for gaps. Coverage of both frameworks is described.



Clear Writing Composition (5 points) The report was easy to read (i.e., flowed logically, used headings/subheadings/exhibits wisely). The report used proper grammar and good spelling, throughout. Appropriate citations were used.



TOTAL SCORE:_____/100

Appendix D

Cover sheet and survey instruments from the 2008 and 2009 studies

Appendix D.1

Coversheet and survey from the 2008 study

IE 470/ISE 5016 Virtual Team Assessment

PURPOSE

The purpose of this survey is to gather information regarding the virtual team that you participated in for IE 470 at OSU or ISE 5016 at VT. More specifically, this survey has been designed to understand the processes and infrastructure needed to support virtual student project teams. The following questions are intended to be used to help assess what went well and what opportunities for improvement exist. Some questions will ask what processes your team used to complete the project. Some question will ask about the systems you used to support your virtual team processes. Finally, some question will ask about the interactions between team members.

YOUR PARTICIPATION

In order to accomplish these goals, your complete and honest feedback is needed. Please indicate your team number (1 – 11) at the top of the survey. You do not need to include your name. All responses will remain confidential. Your responses will not impact your standing as a student at OSU or VT or your grade in IE 470 or ISE 5016. If you have any questions about this survey or about the questions on the survey, you can contact Dr. Doolen at doolen@engr.orst.edu or at 541.737-5641.

Virtual Team Number (Include your assigned team number between 1 and 11)_____	Strongly Disagree	Disagree	Tend to Disagree	Tend to Agree	Agree	Strongly Agree
Circle the response that BEST describes your opinion.						
1. During our team's first meeting, some time was dedicated to discussing the team's purpose and goals.	1	2	3	4	5	6
2. Our team dedicated some time during project meetings to team building exercises.	1	2	3	4	5	6
3. Team members trusted one another and consulted with each other throughout the project.	1	2	3	4	5	6
4. Team members experienced a sense of shared goals and objectives.	1	2	3	4	5	6
5. Knowledge and information sharing was understood to be a group norm for our team.	1	2	3	4	5	6
6. Our team was a very cohesive unit.	1	2	3	4	5	6
7. When disagreements occurred, they were usually addressed promptly.	1	2	3	4	5	6
8. Team members regularly used conference calls or phone calls to share information.	1	2	3	4	5	6
9. Team members regularly used e-mails to share information.	1	2	3	4	5	6
10. Team members regularly used instant messaging to share information.	1	2	3	4	5	6
11. Team members regularly used web postings to share information.	1	2	3	4	5	6
12. Team members regularly used NetMeeting to share information.	1	2	3	4	5	6
13. Team members regularly used web cameras to share information.	1	2	3	4	5	6
14. Team members used their own judgment when solving problems.	1	2	3	4	5	6

	Strongly Disagree	Disagree	Tend to Disagree	Tend to Agree	Agree	Strongly Agree
Circle the response that BEST describes your opinion.						
15. Time was dedicated to developing social relationships between our team members.	1	2	3	4	5	6
16. Team members recognized our collective talents.	1	2	3	4	5	6
17. Team members had a shared understanding of the project's goals and objectives.	1	2	3	4	5	6
18. Team members were clear on how to best perform our tasks.	1	2	3	4	5	6
19. Our team used an established process for making decisions.	1	2	3	4	5	6
20. I had access to all of the information that I needed to work on this project.	1	2	3	4	5	6
21. Our team had access to the tools needed to work on this project.	1	2	3	4	5	6
22. Our team had access to the technologies needed to work on this project.	1	2	3	4	5	6
23. Team members were in contact with each other on a regular basis throughout this project.	1	2	3	4	5	6
24. Overall, the electronic methods we used to communicate with one another were effective.	1	2	3	4	5	6
25. Our team completed tasks on time.	1	2	3	4	5	6
26. Our team met the deadlines we set for ourselves.	1	2	3	4	5	6
27. There was respect for individuals in this team.	1	2	3	4	5	6
28. I felt my input was valued by members of this team.	1	2	3	4	5	6
29. Team member morale was high.	1	2	3	4	5	6
30. I enjoyed being a member of this team.	1	2	3	4	5	6
31. In the future, I would be interested in participating in another virtual team.	1	2	3	4	5	6

32. Please indicate the typical frequency with which you used the following tools for exchanging information communicating with team members during the project.

0 – Never/Not applicable 1 = Once 2 = Twice
3 = Weekly 4 = A few times each week 5 = Daily during the project

_____One to one phone call
_____Group teleconference using a polycom or speaker phone
_____Web conference using only a web camera
_____Conference with both the polycom and a web camera
_____Other _____ (please specify)
_____Shared databases or groupware
_____Instant Messaging
_____Web Postings
_____E-mail
_____NetMeeting

Please include any other comments about your participation in the IE 470/ISE 5016 Virtual Team Project that you wou

Appendix D2.1
Cover sheet used in the 2009 study

Dear Student,

Your help is needed for an important research project. Mark Bonnono, a master's student in the Department of Mechanical, Industrial and Manufacturing Engineering, is working on a research project for his thesis involving virtual teams. A virtual team is a group of individuals, who collaborate together but are separated by time, space, and/or distances. Virtual teams generally use information technology (such as email, audio/video conferencing or instant messaging services) to achieve their goals.

To date there has been some research to determine how a virtual team can ensure their ability to be successful, but the subject is still poorly understood. In this study, the effects of implementing shared ownership in the early stages of a virtual team's project will be explored.

Your participation is being requested to help explore the impact of shared team tasks on your team's performance. In your class you have been working in a virtual project team. On the next page you will find a short survey about your virtual team experience.

The survey should take about 5-10 minutes to complete. Completing the survey is voluntary. There are no foreseeable risks or benefits from completing this survey. There will be no penalty to your grade or your standing in the university if you choose not to participate. Do not include your name or any other personal identifier on the survey. The confidentiality of your responses will be protected to the extent permitted by law.

If you wish to participate, please respond to the questions starting on the next page. Fill in your team number and then read the instructions at the top of the survey.

Thank you for your help in this important research. If you have any questions or comments, please contact Mark Bonnono, bonnono@onid.orst.edu or Dr. Toni Doolen, toni.doolen@oregonstate.edu. If you have any questions about your rights as a research subject, please contact the Oregon State University Institutional Review Board (IRB) Human Protections Administrator, OSU Research Office, and (541) 737-4933, irb@oregonstate.edu.

Please detach this cover letter from the survey and keep it for your records.

Appendix D.2.2

Survey used in the 2009 study

Team Name:_____

Instructions:
Rate on a scale from 1-5 your level of agreement with each of these statements as it pertains to your virtual team experience in this class. Select only ONE response per statement.

		Not at All	A little bit	Somewhat	Mostly	Completely
1	My team has a good understanding of each other's task-related knowledge.	1	2	3	4	5
2	The final project deliverable, for my team, will be exceptionally good.	1	2	3	4	5
3	My team takes advantage of the specialized skills each team member possesses.	1	2	3	4	5
4	My team has a shared understanding of how each team member can best contribute to the project.	1	2	3	4	5
5	My team has a good understanding of each other's task-related skills.	1	2	3	4	5
6	My team has a clear understanding, shared by all team members, of how information should be communicated.	1	2	3	4	5
7	I really feel that I am a part of my team.	1	2	3	4	5
8	My team takes advantage of the specialized knowledge each team member possesses.	1	2	3	4	5
9	My team has performed to the best of our ability.	1	2	3	4	5
10	I have learned a lot from the other members of my team.	1	2	3	4	5
11	The work my team has produced so far is exceptionally good.	1	2	3	4	5
12	I'd like to work with my team again.	1	2	3	4	5
13	My team will earn an A on this project	1	2	3	4	5
14	I enjoy working with my team.	1	2	3	4	5
15	When communicating, my team members are careful to ensure that all information can easily be understood.	1	2	3	4	5
16	My team has a clear understanding, shared by all team members of what all is needed to complete our project.	1	2	3	4	5

The following questions will not be used for identification purposes. All responses are voluntary.

Please fill in the blank.

1. **Age: _____**

Please circle the appropriate response for each of the following questions.

2. **Gender:** Male Female
3. **What year are you in your program:** Freshman-Sophomore Junior-Senior Graduate Student
4. **Is English your first language?** Yes No
5. **Have you previously had any experience working in a virtual team or previously taken any classes covering the subject of virtual teams?** Yes No

Appendix E
Each charter assignment and grading rubric used to evaluate completed charters

Appendix E.1
Team Charter Assignment-A

Team Charter Assignment-A

Include the following sections in your team Charter:

Group Objectives
What organizational system has the group chosen for the design activity? What are the group's objectives? Objectives should define more specifically what the group will accomplish. These may be related to the design project and to group/individual learning. Groups should also discuss academic performance goals, related to their course grades, i.e. be clear about what grade and level of effort each group member is expecting.

Target Organization Overview
Provide a brief overview of the organizational system. This description could include an overview of key business processes, products/services, customers, whether part of a higher-level system, etc.

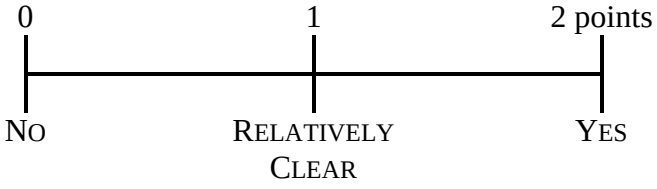
Group Processes
What key processes will the group use to manage the project work? For example, how will the group make decisions? How often will the group meet? What technology will the group use for its meetings? How will the group maintain documents?

Roles
What tasks need to be performed? Who will be responsible for the tasks? Groups may assign roles such as group leader, documentation coordinator, note taker, etc. Groups may also want to include a Gantt chart mapping out tasks, milestones, and target dates.

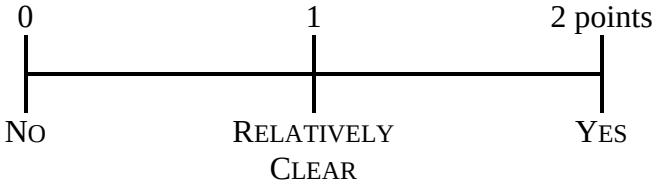
Principles of Operation
What principles, or ground rules, will the group use to guide decisions and behaviors?

IE 470 TEAM CHARTER ASSIGNMENT-A GRADING RUBRIC

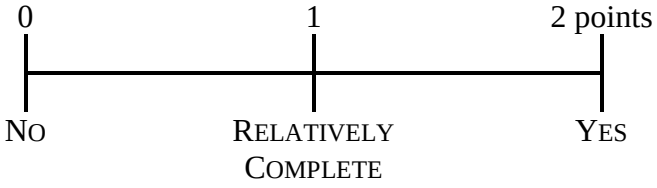
Target Organization Overview: (2 points) Provides a clear overview of the organizational system the group is doing the project on.



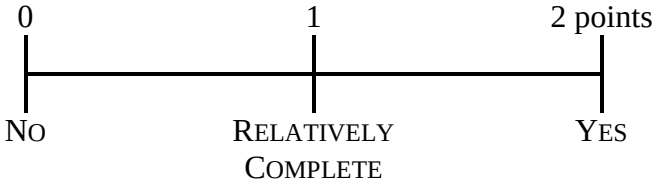
Group Objectives: (2 points) Provides a list clear team objectives the group will strive to meet while working on the virtual team.



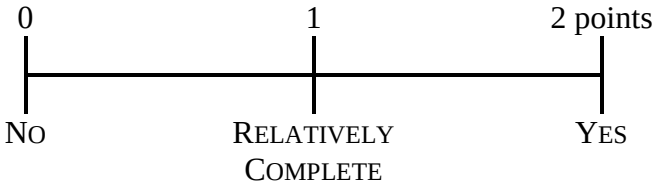
Group Processes: (2 points) Provides a complete list of the key processes the group will use to manage the project. (i.e. how will the team make decisions, how often will the team meet, what technology will the team use, etc.)



Roles: (2 points) Provides a complete list of the roles each team member will play while participating on the project.



Principles of Operation: (2 points) Provides a complete list of the ground rules the group will use to guide decisions and behaviors, during the project.



TOTAL SCORE:_____/10

Appendix E.2
Team Charter Assignment -B

Team Charter Assignment -B

Include the following sections in your team Charter:

Target Organization Overview
Provide a brief overview of the organizational system. This description could include an overview of key business processes, products/services, customers, whether part of a higher-level system, etc.

Team Goals
Provide a list of the team goals. Goals can include quality goals, learning goals, communication goals, etc.

Skills Inventory
Provide a list of the team member skills, deemed applicable to the project that each team member possesses. Also include a list of individual developmental needs of team members; specifying any skills team members would like to develop while working on the project.

Ground Rules
Provide a list of ground rules that the team will follow while working on the virtual team. These rules should include ground rules to be followed, expectations of team members, rules for online meetings, participation/commitment levels expected from all team members, and a chosen time frame for how soon after an email is sent that it needs to be responded to.

Personality Type/Learning Style:
Provide a list of each team member with the team member's personality types and learning styles listed. Both the personality type and learning style should be written in a way to help all the other team mates understand everyone else's personality and learning style, as they relate to social team dynamics.

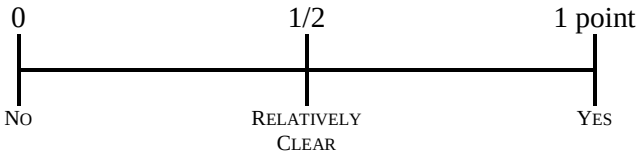
Potential barriers and coping strategies:
Provide a list of all potential barriers the team believes they may face while work on the project. Also include a strategy to the team will use to cope with and overcome these barriers.

Conflict Management Strategies:
Provide a conflict resolution strategy that will be used by the team for if and when conflicts arise during the project.

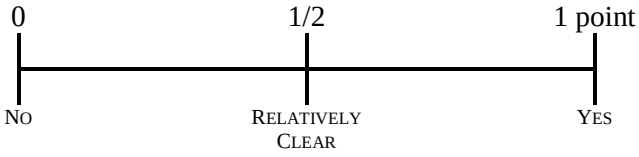
Standards for Availability:
Provide a list of the times that the team will be unable to meet do to time zone differences, personal commitments, etc.

IE 470 TEAM CHARTER ASSIGNMENT-B GRADING RUBRIC

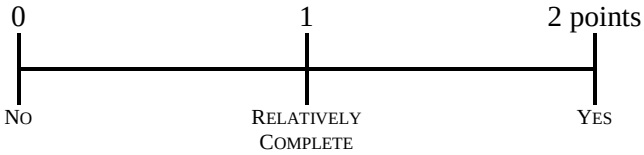
Target Organization Overview: (1 point) Provides a clear overview of the organizational system the group is doing the project on.



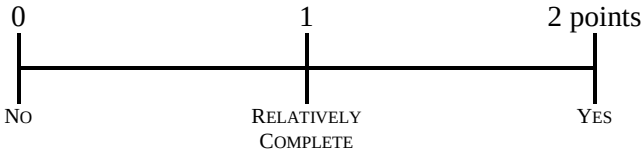
Team Goals: (1 points) Provides clear team goals, making mention of the quality and learning goals of the team.



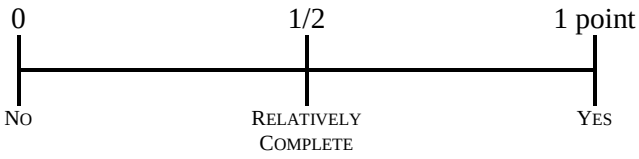
Skills Inventory: (2 points) Provides a complete list of the skills inventories of all team Members along with any development needs/wants of all team members



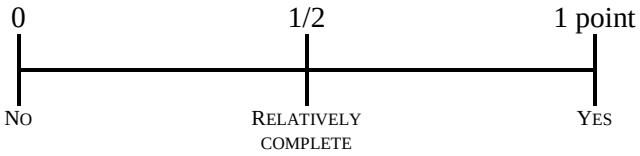
Ground Rules: (2 points) Provides a complete list of ground rules, email response requirements, rules for online meetings, and expectations of the team.



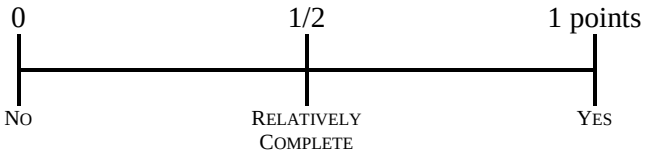
Personality Types/Learning Styles: (1 point) Provide as list of all the personality types and learning styles of all the members on the team.



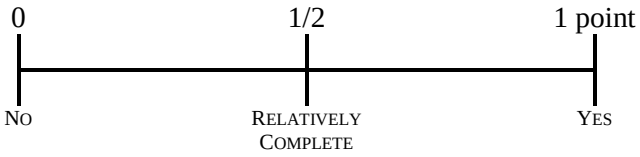
Potential Barriers & Coping Strategies: (1 points) Provides a complete list of potential barriers that may hinder the team.



Conflict Management Strategies: (1 point) Provides a thought out and clear strategy for dealing with conflict for when/if it arises.



Standards for Availability: (1 point) Provides a reasonable list of times when the team is Unable to meet.



TOTAL SCORE:_____/10