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UNDERSTANDING THE ADAPTIVE USE OF VIRTUAL WORLD TECHNOLOGY CAPABILITIES AND TRUST IN VIRTUAL TEAMS

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UNDERSTANDING THE ADAPTIVE USE OF VIRTUAL WORLD TECHNOLOGY CAPABILITIES AND TRUST IN VIRTUAL TEAMS

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ABSTRACT

In an environment of global competition and constant technological change, the use of virtual teams has become commonplace for many organizations. Virtual team members are geographically and temporally dispersed, experience cultural diversity, and lack shared social context and face-to-face encounters considered as irreplaceable for building and maintaining trust. Previous research has established that higher trusting teams have better cooperation and experience improved outcomes; however, trust building in a team where members are from different backgrounds, time zones and cultures is a considerable challenge. Virtual teams (VTs) rely heavily on technology to facilitate coordination, communication, and control in the team. One particular technology that has generated great interest as a viable tool in VTs is broadly referred to as metaverses. Metaverses provide unique technology capabilities that allow individuals to interact in a three-dimensional space. Unique capabilities such as visual communication among avatars, video and audio chat, and the communication of deliberate body language through gestures and other nonverbal cues may provide opportunities for VTs, particularly in relation to trust building. The broad goal of this research is to increase our understanding of the relationship between virtual team members and information technology during the development of trust. Specifically, this thesis focuses on understanding the relationship between metaverse technology capabilities and trust development between VT members by studying how technology capabilities are used and modified to shape trust in general and interpersonal trust in particular.

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"Two roads diverged in a wood, and I – I took the one less traveled by, and that has made all the difference." Robert Frost.

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CHAPTER 1: INTRODUCTION

"The reasonable man adapts himself to the world; the unreasonable one persists in trying to adapt the world to himself. Therefore, all progress depends on the unreasonable man." -George Bernard Shaw

In an environment of global competition and constant technological change, the use of virtual teams (VTs) has become commonplace for many organizations, even if their limitations are not fully recognized or resolved. Virtual teams are known as flexible units that can be used to bring together individuals with varying skill sets and knowledge from different geographic locations and rely heavily on technology and computer mediated communication (CMC) tools to facilitate coordination, communication, and control in the team. Continuing advances in information technology (IT), combined with a more flexible approach to job design, have led to increasing numbers of people working away from traditional company offices. Increasingly, enterprises have employees working together on projects who are not physically present at the traditional premises of the organization. These remote workers have the same responsibilities and challenges as onsite employees with added constraints brought about by meeting in cyberspace. One of these constraints is the lack of face-to-face interaction, which is known to affect the building of trust.

The issue of trust is particularly important in the context of VTs. VTs exist under conditions of uncertainty and complexity, therefore, coordinated action is more effective if trust is present (Peters & Manz, 2007). In VTs, the development of relationships is difficult because the social dimensions of working together virtually are not enacted in

the same manner as when teams are co-located (Greenberg, Greenberg, & Antonucci, 2007). Technology becomes the conduit for communication and coordination as team members conduct work across geographic, temporal, and cultural boundaries.

Trust develops differently in VTs than in co-located teams and the way trust develops in VTs may change as technology continues to evolve. As such, technology is an integral part of work practices and it is important to understand how technology interacts with team processes to affect trust. Advances in IT have also led to technology developments in the area of virtual worlds. VWs offer unique capabilities that allow users to interact in ways that are similar to face-to-face interactions, but may provide abilities to exceed or accelerate trust development based upon the technology capabilities available. This dissertation focuses on understanding the relationship between the adaptation of technology and trust by studying how the unique technology capabilities available in virtual worlds shape trust in VTs.

1.1 Importance of the Topic

This topic is important for several reasons. First, organizations rely heavily on VTs. As the practice of VTs becomes increasingly common, it is essential to understand how to make these teams successful, particularly with regard to developing trust.

Second, previous research has established that higher trusting teams have better cooperation and team performance (e.g., Meyerson, Weick, & Kramer, 1996; Powell, 1996; Blomqvist, 1997; Iacono & Weisband, 1997; Jarvenpaa, Knoll, & Leidner, 1998; Jarvenpaa & Leidner, 1999). Specifically, high trusting VTs often experience improved outcomes (Jarvenpaa et al., 1998; Powell, Piccoli, & Ives, 2004). Studies have found that

team members are more willing to contribute and cooperate if they trust one another (Mayer, Davis, & Schoorman, 1995; Jarvenpaa et al., 1998; Powell, et al., 2004). Without trust, team members may not share information openly and workers may change the nature of collaboration to avoid the need for close coordination (Das & Teng, 1998; Herbsleb, Mockus, Finholt, & Grinter, 2000) or may simply avoid collaborating with others altogether, thus limiting their productive capacity (Teasley, Covi, Krishnan, & Olson, 2000). Understanding the dynamic nature of trust in teams where members come from different backgrounds, time zones and cultures is a considerable challenge.

Third, technology is continually evolving and this evolution can offer new opportunities for organizations, and this also applies to VTs. VWs offer a new way to connect globally dispersed employees. It is important to examine how new and improved technology capabilities can impact or change our current understanding so that teams can leverage these new capabilities.

Finally, trust is a complex topic and there are often inconsistencies in the literature with regard to trust concepts. Trust is a multi-dimensional construct and there are variations with regard to the definitions and components of trust (see Hakonen & Lippon, 2009 & Zolin, Hinds, Fruchter, & Levitt, 2004). This dissertation addresses these inconsistencies by clarifying the definition and measurement of trust.

1.2 Problem Statement

Some assume that we need physical interaction in order to trust people and build social relationships (Hung, Dennis, & Robert, 2004). However, this assumption may no longer be valid due to the changing nature of virtual work. Communication among VT

members is often limited within the boundaries of the technology. As such, technology enabled communication typically does not convey the same richness of emotion and reaction as face-to-face communication (Greenberg et al., 2007).

In face-to-face encounters, people form an impression of others based on direct and indirect signs (perceived properties of objects or events) and signals (perceived properties of objects or events with an intended communicative function) (Bacharach & Gambetta, 1997; Hung et al., 2004; Donath, 2006). Visual and auditory cues used in the construction of cognitive models of trusting intentions (trustfulness) and trusting beliefs (trustworthiness) are not necessarily available in computer-mediated settings (Riegelsberger, 2005). Examples of visual cues include physical appearance, posture, gestures, body movements, and nonverbal cues. In computer-mediated situations, visual cues used to form an impression are limited due to the technological inability to mediate many of the cues available in face-to-face settings. When developing trust, communication in VTs must be much more explicit because members cannot see non-verbal cues such as facial gestures, nods of assent, or heads shaking in agreement or disagreement. Additionally, what constitutes as appropriate written responses to replace body language may not be understood to team members and may be different in different cultures (Greenberg et al., 2007). In the absence of these signs and signals, team members fall back on inferred information that may lead to erroneous judgments of trust and a more fragile form of trust. As a result, trust forms from inferred information or stereotypes (Cramton, 1997; Hung et al., 2004; Riegelsberger, 2005). Since nonverbal cues are central to the communication of trust (Ekman & Friesen, 1974; Takeuchi &

Nagao, 1993; Walther & Tidwell, 1995; Kasper-Fuehrer & Ashkanasy, 2001), this situation represents a shift in the way that trust develops in VTs. Therefore, due to the limited richness of communication and the lack of these types of signs and signals, VT members are likely to encounter problems in developing trust.

Since VTs rely heavily on technology to facilitate coordination, communication, and control in the team, it is important to understand how technology can affect the development of trust. One particular technology that has generated great interest as a viable tool in VTs is broadly described as metaverse technology. Metaverses are three-dimensional virtual worlds[1] (VWs) where people interact with each other and their environment, using the metaphor of the real world but without its physical limitations (Davis, Murphy, Owens, Khazanchi, & Zigurs, 2009). These environments, once considered for just gaming and social interaction, are also being used in business for employee training, to save money on travel and conference expenses, and Internet marketing (Nevo, Nevo & Carmel, 2011; Shen & Eder, 2009; Ives & Junglas, 2008; Kahai, Carroll, & Jestice, 2007). For example, IBM is using VWs for massively parallel online conferences where employees from around the world come together in the VW to jointly share knowledge and generate valuable ideas (Füller, Müller, Hutter, Matzler, & Hautz, 2012).

Recent exploratory studies of the use of VWs in VTs have highlighted that technology capabilities offered by these tools can affect team outcomes and performance (Owens, Mitchell, Khazanchi, & Zigurs, 2011). For example, although VW technology

[1] A VW is an instantiation of a metaverse and this term is most commonly used when discussing three-dimensional spaces, therefore, the term VW will be used subsequently throughout the study.

can simulate some face-to-face interactions, it also provides important and useful differences that go beyond the ability to simply just replicate face-to-face communication (Owens et al., 2011). Studying how people adapt the unique three-dimensional technology capabilities may offer insights into the dynamic nature of trust in VTs and help us understand how the use of advanced technologies can affect trust in VTs.

VWs offer a richer communication medium than traditional and more commonly used communication technologies such as email, instant message, and video/audio conference. These environments support three-dimensional visual representations of objects and people and also incorporate multiple communication modes (text, audio, and visual based). VW technology capabilities (VWTCs) allow users the ability to mimic physical characteristics and actions in the virtual environment. The important visual cues, physical appearance, posture, gestures, body movements, and nonverbal cues that are used in the development of trust are now available using the capabilities offered in a virtual world. In a VW, people are represented by avatars. Avatars have their own physical appearance and can be dressed for various occasions. Avatars can also change their gaze and positioning to indicate the direction in which the user is looking and can be used to engage other users or to direct attention to a particular item of interest. Avatars also have the option to perform gestures that mimic normal human nonverbal communications (Moore, Ducheneaut, & Nickell, 2007). Therefore, avatar appearance, body movements, and nonverbal actions in a three-dimensional space could potentially affect trust development in VTs.

1.3 Research Question

The focus of this dissertation is on increasing our understanding of the dynamic nature of trust in virtual teams by examining the relationship between trust and VW technology capabilities. Specifically, this research is guided by the following research question: *How does the use of virtual world technology capabilities affect the development of trust in virtual teams?*

1.4 Research Goals

There are several goals of this dissertation. One aim is to clarify the definition of trust by defining the different dimensions of trust and explaining how those dimensions relate to the overall concept of trust. In doing such, the goal is to provide additional details surrounding the measurements used for the specific dimensions of trust. Using the specific definitions and measurements of trust, the dissertation will examine the relationship between VWTCs and the development of individual trust, with the goal of offering explanation on how the use of specific VWTCs affect the development of individual trust in VTs.

1.5 Summary of the Introductory Chapter

To summarize, trust is important in VTs and the absence of trust can potentially have a negative effect on team outcomes. Technology is critical, particularly for VTs; however, traditional CMC technologies lack the ability to transmit important signs and signals, or nonverbal cues, important in building trust and assessing trustworthiness. This research focuses on understanding the relationship between technology and trust by studying how the adaptation of VWTCs shapes trust in VTs. The study helps fill the gap

in extant research, namely, the relationship between the use of virtual world technology capabilities and trust in VTs.

1.6 Organization of the Dissertation

This dissertation is organized into six chapters. This section completes the introduction and overview of the research. The remaining chapters are organized as follows:

Chapter 2: Theoretical Foundations. This chapter guides the reader through a review of relevant prior research and literature in the areas of interest for this research, specifically trust, virtual teams, and technology adaptation.

Chapter 3: Conceptual Model and Research Propositions. Chapter 3 contains the conceptual model and propositions that guide the research.

Chapter 4: Research Method. This chapter presents the details surrounding the research methods used to study the conceptual model and collect the data.

Chapter 5: Analysis of Results. Chapter 5 presents a discussion of the data collected in the study and the analysis of the results in relation to the propositions.

Chapter 6: Discussion, Implications, and Conclusions. The final chapter presents findings and implications based on the data analysis in the previous chapter. This chapter also presents strengths, limitations, and contributions for research, practice, and areas for future research.

CHAPTER 2: THEORETICAL FOUNDATIONS

Before presenting research on what we know and what we do not know relating to trust in VTs, this chapter presents a comprehensive definition of trust. The chapter also includes a discussion of relevant theories as they relate to the development of trust and the use of technology in VTs. This information provides the foundation for the conceptual model presented in the proceeding chapter.

2.1 Trust

Trust is ubiquitous in human interaction and spans interdisciplinary fields including philosophy, computer science, economics, and organizational behavior. Researchers have presented varying definitions and dimensions of trust while studying this concept in various contexts. Prior research on trust, specifically in VTs, has been extensive, spanning a number of years (Mitchell and Zigurs, 2009). A study by Mitchell and Zigurs (2009) provided an extensive literature review on trust in VTs and identified key research papers relevant to the topic. Their paper provided a framework for research in identifying relevant definitions of trust. These definitions share common attributes that are important to developing a common definition.

Table 2.1 summarizes the various definitions of trust found throughout the literature and each definition is characterized by key attributes.

Table 2.1: Definitions of Trust

Definition	Attributes	Citation
The mutual confidence that no party to an exchange will exploit another's vulnerabilities and an exchange partner is one who is trustworthy when it is worthy of the trust of others (pg. 176).	Mutual Confidence Vulnerability	Barney & Hansen (1994)
The willingness to be vulnerable under conditions of risk and interdependence. Trust is not a behavior or a choice, but an underlying psychological state that can cause or result from such actions.	Conditions of Risk Vulnerability Psychological state	Bhattacharya et al. (1998)
Expectation of another's capability, goodwill and self-reference visible in mutually beneficial behavior enabling cooperation under risk.	Expectation Conditions of Risk	Blomqvist (2002)
A psychological state involving confident positive expectations about another's motives with respect to one's self in situations that entail risk (pg. 194).	Psychological state Expectations Conditions of Risk	Boon & Holmes (1991)
The belief that an 'individual or group a) makes good faith efforts to behave in accordance with any commitments both explicit and implicit, b) is honest in whatever negotiations preceded such commitment and c) does not take excessive advantage of another even when the opportunity is available'.	Beliefs Vulnerability	Cummings & Bromley (1996)
Actions that (a) increase one's vulnerability (b) to another whose behavior is not under one's control, (c) in a situation in which the penalty (disutility) one suffers if the other abuses that vulnerability is greater than the benefit (utility) one gains if the other does not abuse that vulnerability.	Vulnerability	Deutsch (1962)
Trust develops through frequent and meaningful interaction, where individuals learn to feel comfortable and open in sharing their individual insights and concerns, where ideas and assumptions can be challenged without fear or risk of repercussion and where diversity of opinion is valued over commonality or compliance (pg. 36).	Expectation	Holton (2001)
The expectation by one person, group, or firm of ethical behavior, that is, morally correct decisions and actions based upon ethical principles of analysis, on the part of the other person, group or firm in a joint endeavor or economic exchange (p. 399). Expectation of fair behavior.	Expectation	Hosmer (1995)
Expectation that others will behave as expected (p. 31).	Expectation	Jarvenpaa, et al. (1998)
A state involving confident positive expectations about another's motives regarding oneself in situations of risk. These expectations may be based on the rewards or punishments that guide other's behavior (calculus-based trust), the predictability of the other's behavior (knowledge-based trust), or a full internalization of the other's desires and intentions (identification based trust).	Expectation Conditions of risk	Lewicki & Bunker (1995)
The extent to which an individual believes in (and is willing to base his or her own actions on) another person's actions and decisions to take further action.	Belief	Luhmann (1979)
The willingness of a party to be vulnerable to the actions of another party based on the expectation that the other will perform a particular action important to the trustor, irrespective of the ability to monitor or control that other party (p. 712).	Vulnerability	Mayer et al. (1995)
The extent to which a person is willing to act on the basis of the words, actions, and decisions of another.	Trusting Intentions	McAllister (1995)
A psychological state comprising the intention to accept vulnerability based on positive expectations of the intentions of behavior of another (pg. 395).	Psychological state Vulnerability	Rousseau, et al. (1998)
The conscious regulation of one's dependence on another that will vary with the task, the situation, and the other person.	Dependence	Zand (1972)

A review of these definitions highlights several key characteristics of trust. Trust is:

- a psychological state
- an expectation of another's motives, ability, fair behavior, or intentions of behavior
- an expectation irrespective of the ability to monitor or control the other party
- vulnerability under conditions of risk
- dependence on another that varies based on the task, situation, and other person
- a combination of trusting intentions and trusting beliefs

Therefore, based on definitions found in prior literature, this study comprehensively defines ***trust*** as *a psychological state held by an individual involving vulnerability under conditions of risk where an individual has an expectation of another's motives, ability, and/or fair behavior and one's willingness to depend on another irrespective of their ability to monitor or control the other party.*

2.1.1 Dimensions of Trust

During the review of trust definitions, it was noted that trust is a multidimensional construct and a combination of trusting intentions and trusting beliefs. The various dimensions of trust are often used interchangeably and sometimes erroneously when referring to trust. This study presents trust as two separate but related components – trustfulness (trusting intentions) and trustworthiness (trusting beliefs). This section describes the various dimensions of trust which will be presented as layers. As each layer is peeled away, the goal is to inform the reader of the specific trust related influences on

the concepts of trustfulness and trustworthiness, which are specific dimensions of trust and the focal points for this study. Figure 2.1 presents the dimensions or layers of trust specific to this study followed by a detailed discussion of each layer.

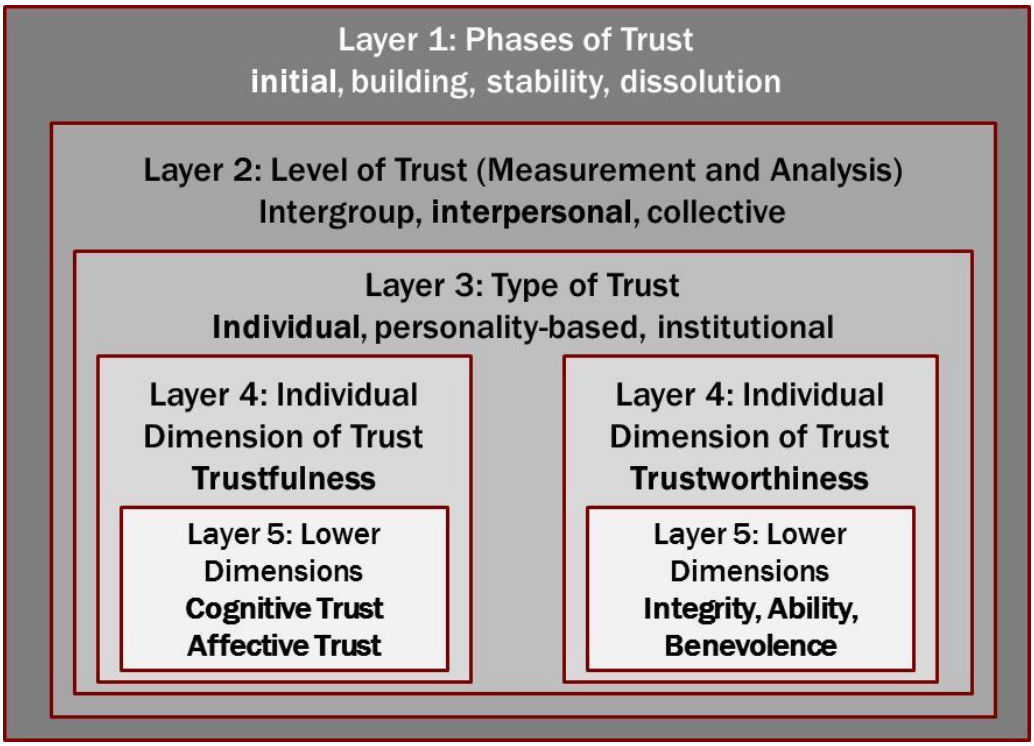


Figure 2.1: Layers of Trust

2.1.1.1 Layer 1: Phases of Trust.

Trust develops over time and may exist at varying levels at different points in a relationship. There are four phases of trust: initial trust development, trust building, stability, and dissolution (Rousseau et al., 1998).

Table 2.2: Phases of Trust

Phase of Trust	Definition
Initial Trust Development	Based on an individual's disposition to trust that enable one person to trust another without previous firsthand knowledge of the other party (McKnight et al., 1998)
Trust Building	Process of forming or reforming trust (Rousseau et al., 1998)
Stability	Maintaining already existing trust (Rousseau et al., 1998)
Dissolution	The decline of trust (Rousseau et al., 1998)

This research focuses specifically on initial trust development and trust building.

2.1.1.2 Layer 2: Levels of Trust.

Trust exists at different levels within a team and has been studied at these various levels. Specifically, trust can be studied at the intergroup level (Us/Them), the collective level (We/Our), or the interpersonal level (You/I) (Newell, David, & Chand, 2007). When studying trust it is important to specify the level of analysis in order to ensure appropriate measures are used. The focus of this research is on interpersonal trust, using the individual as the level of analysis. The individual level was chosen because of the unique way one can adapt technology capabilities in a VT.

2.1.1.3 Layer 3: Types of Trust.

There are various types of trust and each type can have an effect on the overall level of trust in a relationship. Individual trust, personality-based trust and institutional-based trust are types of trust that best describe trust between virtual team members (Sarker, Valacich, & Sarker, 2003; Peters & Manz, 2007).

Individual trust is an expectancy held by an individual or a group that the word, promise, verbal or written statement of another individual or group can be relied upon. One's individual trust within the VT is influenced by one's disposition to trust (personality-based trust) and institution-based trust. ***Personality-based trust*** *is defined as*

one's disposition to trust or tendency to be willing to depend on others (McKnight, Cummings, & Chervany, 1998). Personality-based trust is formed based on a person's trusting nature and develops early, typically during childhood (Bowlby, 1982; Rotter, 1967; Erikson, 1968; Sarker et al., 2003). Personality-based trust determines a person's willingness to depend on others (Driscoll, 1978; Mayer et al., 1995; McAllister, 1995) and has an effect on one's trusting intentions and trusting beliefs.

Institution-based trust *is a function of an individual's belief in institutional norms and procedures and develops as organizational rules and norms guide an individual's behavior* (Sarker et al., 2003). This type of trust helps an individual gain confidence in another's behavior based on the norms and rules in the institution (organization) (Scott, 1996). These norms help control opportunistic behavior, thus fostering a trusting environment. Institution-based trust reflects the security one feels about a situation because of guarantees, safety nets, or other structures (Shapiro, 1987; Zucker 1986). Table 2.3 provides a summary of definitions for these different types of trust.

Table 2.3: Types of Trust

Construct	Definition	Citation
Individual trust	a psychological state held by an individual involving vulnerability under conditions of risk where an individual has an expectation of another's motives, ability, and/or fair behavior and one's willingness to depend on another irrespective of their ability to monitor or control the other party.	Owens, 2012
Institution-based trust	a function of an individual's belief in institutional norms and procedures and develops as organizational rules and norms guide an individual's behavior	Sarker et al., 2003
Personality-based trust	one's disposition to trust or tendency to be willing to depend on others	McKnight et al., 1998

2.1.1.4 Layer 4: Dimensions of Individual Trust.

Previous research studies consider individual trust as comprised of two components – trusting intentions (trustfulness) and trusting beliefs (trustworthiness) (McKnight et al., 1998; Chou et al., 2008). These dimensions look at different aspects of individual trust. Trusting intentions or ***trustfulness*** is defined *as one's willingness to depend on another in a given situation* (e.g., Currall & Judge, 1995). Trustfulness refers to how one trusts other team members (Chou et al., 2008). This concept has also been referred to as propensity to trust in prior literature (i.e. Jarvenpaa and Leidner, 1999). Trusting belief or ***trustworthiness*** is *one's belief that another person is benevolent, competent, honest or predictable in a situation* (Mayer et al., 1995). Trustworthiness refers to how another team member is trusted (Chou, Wang, Wang, Huang, & Cheng, 2008). This study attempts to examine both dimensions of trust.

There are inconsistencies in prior research relating to these terms. Some studies measure benevolence, integrity, and ability and group these into an overall measure of trust (i.e. Hakonen & Lipponen, 2009). Others focus on trust and use varying measures of trustworthiness and trustfulness to measure trust, but do not distinguish these terms in the study (i.e. Jarvenpaa et al., 1999). There are also those studies that look at one of these components, but not both. One particular study looks at parts of both components, but groups the results into an overall measure of trust (Chou et al., 2008). This research attempts to bring clarity to the notion of trust by separating trust into two different dimensions and using validated measures available for measuring those dimensions.

2.1.1.5 Layer 5: Dimensions of Trustfulness and Trustworthiness.

Trustfulness has both cognitive (e.g. competence, reliability, professionalism) and affective dimensions (e.g. caring, emotional connection to each other) (Kanawattanachai & Yoo, 2005; Meyerson et al., 1996). ***Cognitive trustfulness*** results from a deliberate assessment of another's characteristics and the process of weighting the benefits of trusting over the risks (Sarker et al., 2003). Cognitive trust develops from social cues and impressions that an individual receives from others (Sarker et al., 2003). Social cues and impressions are formed differently when technology is the conduit for communication. We cognitively choose whom we will trust, and under what circumstances, and we base the choice on what we take to be good reasons constituting evidence of displayed eagerness and enthusiasm (Sarker et al., 2003). This type of trust is the result of an evaluation of evidence of performance reliability and competence, which is evaluated differently in VT settings. ***Affect based trustfulness*** involves one's emotional bonds and sincere concern for the well-being of the others (Hung et al., 2004). Affect based trust is the result of the social bonds developed in a relationship in which there is genuine care and concern for the welfare of the other person. This type of trust is based on assessments of benevolence (Greenberg et al., 2007). In virtual settings, social bonds develop differently than they do in face-to-face settings.

An individual's level of *trustworthiness* is dependent on various conditions. Conditions that lead to higher levels of trustworthiness have been considered repeatedly in the literature. For example, some authors identify a single trustee characteristic that is responsible for trustworthiness (e.g. Strickland, 1958), whereas other authors delineate as

many as 10 characteristics (e.g., Butler, 1991). Although a number of factors have been proposed, three characteristics of a trustee appear most often in the literature: ability, benevolence, and integrity. Together, these characteristics affect one's level of trustworthiness. Each contributes a unique perceptual perspective from which to consider the trustee while the set provides a solid and parsimonious foundation for the empirical study of trust for another party. In VTs, trustworthiness is argued to be rooted in perceptions of teammates' ability, benevolence and integrity (Jarvenpaa et al. 1998). ***Ability*** refers to the aptitude and skills that enable an individual to be perceived as competent by teammates (Jarvenpaa et al., 1998, Mayer et al. 1995). ***Integrity*** is the extent to which an individual is believed to adhere to a set of principles thought to make her dependable and reliable. ***Benevolence*** is the extent to which an individual is believed to be willing to help teammates beyond personal motives or individual gain. Mayer et al. (1995) indicate that of the factors identified as contributing to trust – the trustor's belief in the trustee's ability, benevolence and integrity – are mediated by the trustor's propensity to trust which also serves as a direct cause of trust. These factors are evaluated differently in VT settings when technology is the primary means of coordination and control.

To summarize, individual trust is comprised of two components – trustfulness (trusting intentions) and trustworthiness (trusting beliefs and behaviors). Trustfulness has both cognitive and affective dimensions and trustworthiness is based on perceptions of a teammate's ability, benevolence and integrity. Cognitive based trustfulness is modeled as a function of another person's integrity and ability while affect based trustfulness is

based on assessments of benevolence. Table 2.4 provides a summary of the key definitions presented in this section.

Table 2.4: Dimensions of Trust

Construct	Definition
Ability (trustworthiness)	the aptitude and skills that enable an individual to be perceived as competent by teammates
Affect Trust (trustfulness)	one's emotional bonds and sincere concern for the well-being of the others
Benevolence (trustworthiness)	the extent to which an individual is believed to be willing to help teammates beyond personal motives or individual gain
Cognitive Trust (trustfulness)	develops from social cues and impressions that an individual receives from others
Integrity (trustworthiness)	the extent to which an individual is believed to adhere to a set of principles thought to make her dependable and reliable.
Trustfulness	one's willingness to depend on another in a given situation; how one trusts other team member - Trusting intentions
Trustworthiness	one's belief that another person is benevolent, competent, honest, or predictable in a situation; how one is trusted by other members of the team - Trusting belief

2.2 Virtual Teams

Virtual teams have been defined in various ways throughout the literature. Appendix A contains a summary of the various virtual team definitions found in the literature along with their key attributes. The definition used for this study is based upon the common characteristics found among the various definitions, therefore, a ***virtual team*** is defined as *a flexible work team comprised of individuals with different competencies who are dispersed geographically, temporally, culturally, and/or organizationally, and come together for a common goal or specific project and rely predominantly on information technology to communicate and interact with each other.* Virtual teams (VTs) can be temporary or long lasting but typically, teams rapidly form, evolve, and dissolve as needed.

2.3 Initial Trust in Virtual Teams

An individual team member's trusting intentions and trusting beliefs typically form before the team even has its first interaction (Jarvenpaa, Shaw, and Staples, 2004), meaning individuals have preconceived notions of trust prior to meeting or collaborating with their team members. The conventional developmental view of trust maintains that trust starts low and increases as two parties interact (e.g. Butler, 1991; Lewicki & Bunker 1995; Zand, 1972). However, high *initial trust* has been observed in VTs, even during initial phases of team formation (Iacono & Weisband, 1997; Jarvenpaa et al., 1998; Jarvenpaa & Leidner, 1999; Knoll & Jarvenpaa, 1995; Kramer, 1994; Meyerson et al., 1996). This is often referred to as fast trust or swift trust. This high level of initial trust is known to be fragile, however, and dissipates easily. While initial levels of trust may be high due to various factors, it is expected that those initial levels may change over time.

When comparing trust in virtual settings to trust in face-to-face teams, it has been found that over time, trust in virtual settings will rise to levels that meet or exceed the levels of trust in face-to-face teams (Wilson, Straus, and McEvily, 2006). Although trust will increase over time, lower levels of trust can affect team performance (Jarvenpaa, et al., 2004). High early trust can buffer virtual team members from unpredictable and chaotic processes that are characteristic of virtual team interaction (Jarvenpaa et al., 2004).

Table 2.5 summarizes relevant theories relating to initial trust levels in VTs.

Table 2.5: Theories Relating to Initial Levels of Trust

Theoretical Basis		Citation
Swift Trust	Since temporary group members must move forward quickly to accomplish goals, members must act swiftly, as if trust were in place, rather than waiting to see who can be trusted and who cannot.	Meyerson, Weick, & Kramer (1996)
Fast Trust	Enables open tasks and risk taking inherent in a cooperative environment by enabling individuals to take quick actions needed for competitiveness. Fast trust helps individuals to tolerate the inherent uncertainty and vulnerability related to dynamic environments.	Blomqvist (2002)

Initial trust can also be influenced by other things such as personality and organizational factors.

2.4 Relationships among Institution-based trust, Personality-based trust, and Individual trust

As mentioned in the previous sections, there are different types of trust. Specifically, individual trust, personality-based trust and institutional-based trust are types of trust that best describe trust between virtual team members. There are various models and theories that explain the relationship between institution-based trust, personality-based trust, and individual trust. Disposition-based trust theories propose that trust develops based on a person's nature as a trusting or non-trusting person (Rotter, 1971). The trustor's propensity to trust is a characteristic of the trustor, independent of the situation or characteristics of the trustee. This disposition is a function of one's personality, and one's personality, in turn, impacts the quality and effectiveness of a

technology enabled collaboration (Brown, Poole, & Rodgers, 2004). Other models relating to trust suggest that trust does not directly elicit any particular behavior outcomes but influences how people interpret or evaluate information related to attitudes and behavior (Dirks & Ferrin, 2001). One develops beliefs about another's initial trustworthiness based on interpersonal factors and factors related to the situation rather than the trustee's behavior (McKnight et al., 1998). In this view, trust development is an attributional process. Attribution theory suggests that social perceptions arise as people try to explain the past or future actions of others or themselves (Kelley 1967, 1973). Explanation for the actions of others is attributed to internal characteristics when the behavior is inconsistent with prior expectations. One's trust in another directly affects attitudes. High levels of trust will cause the trustor to hold positive attitudes, such as high satisfaction or perceived high performance. Low levels of trust will yield low satisfaction and low perceived task quality. For example, a member with high trusting disposition may interpret the silence of others as the result of a technical problem rather than the other's unreliability. A member with a negative trusting disposition may in turn interpret the same silence as the other's intentional non-participation. Research on global VTs has confirmed such attribution errors (Cramton, 2001; Piccoli & Ives, 2003).

Social similarity has also been found to be an important factor in trust (Jarvenpaa et al., 1998; Henttonen & Blomqvist, 2005). Information about other individuals reinforces initial trust. However, when evidence of the other members' trustworthiness is not available, some level of trust seems to be built on the expectation of similarity when members are from the same organization. Shared social norms, institutional processes,

and social similarity affect the development of individual interpersonal trust. Institution-based trust involves structural assurance, the belief in structures like guarantees and insurance and situational normality, the belief that the environment is favorable (Giddens, 1984). Giddens' (1984, 1990) work on structuration offers a conceptual lens to understand the relationship between individual action, personal trust relationships and institutional-based trust. Lipnack and Stamps (1997) also illustrate a similar form of trust relationship in many of their anecdotes of effective virtual teamwork. Such trust relationships enabled temporary teams to solve specific problems.

Based on these varying theories, we can see that individual trust within the team is affected by personality-based trust and institution-based trust. Table 2.6 provides a summary of key theories and research models that support the relationship between institution-based trust, personality-based trust, and individual trust.

Table 2.6: Theoretical Foundations for Types of Trust

Theoretical Basis	Description	Citation
Attribution Theory	Social perceptions arise as people try to explain the past or future actions of others. People will interpret their environment in such a way as to maintain a positive self-image.	Kelley (1967, 1973)
Dirks and Ferrin Model	Trust reduces ambiguity and uncertainty in social perceptions so cooperative productivity can take place. Focuses on the consequences of trust.	Dirks & Ferrin (2001)
McKnight Model	Individuals use pre-existing dispositions, institutional expectations, and cognitive processes to make attributions about another's initial trustworthiness. Focuses on the antecedents of trust.	McKnight, Cummings & Chervany (1998)
Structuration Theory	The abstract capacities of institutions are taken as the outcome of human agency, which is reproduced via the action and interaction of individuals. Individual trust is based on practices and processes of the organization such as the workings of specialized knowledge, legitimacy of power relations, and hierarchical order.	Giddens (1984, 1990)

2.5 Adaptation of Technology Capabilities

Information technology (IT) is often viewed in terms of capabilities (Bharadwaj, 2000, Mulligan, 2002). Technology capabilities provide potential features – both current and yet to be discovered – that can be developed for specific functionality. Capabilities are dynamic - they can change with time through the process of users' adaptation and appropriation (Davis et al., 2009). IT capabilities are often bundled together by people to accomplish a specific task or goal. Within the context of VTs, IT capabilities can be adapted by individuals in a way that potentially influences trustfulness and trustworthiness (Majchrzak, Rice, Malhatra, King, & Ba, 2000; Henttonen & Blomqvist, 2005).

Capabilities can be used differently by different individuals. Individuals may use different features of the same system or use capabilities in different ways (Sun & Zhang, 2008). It is the capabilities that are used by a particular individual that define what the system means to them (Sun & Zhang, 2008). Over time, individuals may modify the way capabilities are used. Individuals may use capabilities in a way not only based on vendor specifications, but also in ways that allow them to best complete tasks (Harrison & Datta, 2007). In some cases, individuals adaptively use technology capabilities to find the best fit between tasks and technology. The varying use of technology capabilities among individuals and various factors that affect adaptation suggest that there are multiple aspects of technology adaptation that should be considered when studying adaptation.

Technology adaptation has been impacted by research on task-technology fit, which is based on the idea of finding the appropriate tools or technologies for a specific

task, and a participant's acceptance of new technology determines how and when they will use technology (Technology Acceptance Model -TAM). Therefore, fit is important in the adaptation of VWTCs,

The adaptation of information technology capabilities also draws from Adaptive Structuration Theory (AST). People using technology dynamically create perceptions about which features they will use and how they will use those features. This usage experience affects the way the user adapts the technology in various contexts and may impact the way in which trust develops in the team.

When looking at adaptation of information technology capabilities, it is important to consider the richness of the capabilities themselves. People may adapt specific technology capabilities based on the extent to which a communication medium incorporates face-to-face interaction elements, referred to as media naturalness (Media Naturalness Theory MNT). The level of media naturalness of a given technology could affect the way one adapts technology. "Media that incorporates all the elements of unencumbered face-to-face interaction (e.g., physical presence, ability to see and hear others, synchronicity) will be perceived as more natural for communication than other media. Therefore, the extent to which a communication medium incorporates face-to-face interaction elements defines its degree of naturalness (Kock, 2001, p. 12)." The level of cognitive effort, ambiguity, and physiological factors required in information exchange is used to determine if information exchange is natural compared to face-to-face communication (Kock, 2001). For example, a decrease in the degree of media naturalness of a communication medium would lead to increased levels of cognitive

effort, an increase in ambiguity levels, and a decrease in physiological arousal (DeRosa, Hantula, Kock, & D'Arcy, 2004). Therefore, it is possible that the more natural the medium the more capabilities the user will use which in turn may affect how the user will use specific capabilities. In this study, VWTCs may be more natural for communication and coordination.

Based on this theoretical foundation, the adaptation of technology capabilities includes fit, usage experience, and inclusiveness. Therefore, the way individuals adapt the technology capabilities is based on these three constructs. The theoretical foundation for the adaptation of technology capabilities is summarized in Table 2.7.

Table 2.7: Theoretical Foundations for Adaptation of Technology Capabilities

Theory	Definition	Relation to Adaptation	Examples
Adaptive Structuration Theory (AST) (DeSanctis & Poole, 1994)	Variations in structural features (rules and resources) and spirit, along with contextual contingencies, encourage different forms of social interaction; new structures emerge during appropriation processes, which are also affected by group's internal system.	Inclusiveness Fit	The way the technology is used to perform specific tasks can affect team processes within a team.
Media Naturalness Theory (MNT) (Kock, 2001)	Media that incorporates all the elements of unencumbered face-to-face interaction (e.g., physical presence, ability to see and hear others, synchronicity) will be perceived as more natural for communication than other media (Kock, 2001).	Inclusiveness Fit	The distance between avatars can influence the way the message is interpreted. Avatar body movements, facial expressions and gestures can express the degree of attention or involvement.
Task Technology Fit (TTF) (Zigurs & Buckland, 1998)	An appropriate task/technology fit results in higher performing teams.	Fit	Emoticons used in text-based communications can transmit tone and volume.
Technology Acceptance Model (TAM) (Davis, 1989)	Participants' degree of acceptance of new technology is an additional factor in effective collaboration. Acceptance is the individual's decision about how and when they will use technology.	Usage Experience	The acceptance of the technology will influence the inclusiveness and usage of the technology.

2.6 Relationships among the Adaptive Use of VW Technology Capabilities, Trustfulness, and Trustworthiness

The concept of trust in virtual teams has been examined in a variety of contexts associated with interpersonal and organizational communication and in organizational studies of collaboration (e.g. media richness theory, social presence theory, media

synchronicity theory). Much of this research has focused on the general concept of trust and the richness of the communication medium and its effect on team outcomes. Theoretical evidence supports the relationship between communication and trust in VTs, specifically; the use of communication technology and its effect on trust (Jarvenpaa et al., 1998; Jarvenaa & Leidner, 1999; Hung et al., 2004; Riegelsberger, 2005). However, few research studies have examined the relationship between the adaptation of virtual world technology capabilities and trust. This section provides a theoretical foundation to support and add to our understanding of the relationship between the adaption of VW technology capabilities and trust.

It is not possible to think about individuals having innate levels of trustfulness and trustworthiness independent of the environment (Bhattacharya et al., 1998). The actions of others, the nature of outcomes and the consequences of those outcomes are specific to individuals in the context of their environment (Bhattacharya et al., 1998). Therefore, when studying the concept of trust it is important to consider the context or environment where trust is built. Trust is based on the interaction of all possible actions of others in a relationship. For example, when evaluating trust in VTs, it is important to understand the context of those VTs and the technology used in support of those VTs. In a virtual world, much of this interaction takes place in the virtual environment and interaction and coordination is only possible if trust is present (Peters & Manz, 2007). Prior research has found that when working in VTs, acceptance and adaptation of the technology is a prerequisite for developing trusting relationships (Brown et al., 2004). Trust influences

the perceived usefulness of technology (Pavlou, 2003) and perceived usefulness has a direct effect on intention to participate in technology use (Chau & Hu, 2002).

The **socio-technical view** of work systems highlights the importance of looking at the context of work practices and takes as its underlying premise the interdependencies between people and technology (Bostrom & Heinen, 1977; Adman & Warren, 2000; Lamb & Kling, 2003). Social interaction affects and is affected by technology capabilities, and the adaptation of those capabilities ultimately affects outcomes. Prior research on virtual worlds has used this perspective to explore the social and technical aspects of VT interactions using VWTCs and found that there is a relationship between the social and technical components (Owens et al., 2011). The research found that the interplay between social and technical components affects team processes and project outcomes, the social interaction affects and is affected by technology capabilities, and the emergent use of those capabilities affects outcomes (Owens et al., 2011). This suggests that there could be a relationship between the adaptation of VWTCs and the development of trust in VTs.

In face-to-face encounters people form an impression of others based on signs and signals which can have different modalities related to our senses such as sound, visual, kinesthetic, and touch (Bachrach & Gambetta, 1997; Hung et al., 2004; Donath, 2006). Nonverbal communication is a fundamental component of human interaction and many communication media fail to support this feedback channel effectively (Montoya & Lockwood, 2011). Visual and auditory cues (physical appearance, gestures, body movements, posture and nonverbal cues) used in the construction of trustworthiness are

not necessarily available in most mediated settings (Riegelsberger, 2005). Prior research has found that facial displays can improve subsequent interactions and can increase the level of trust in a relationship (Takeuchi & Nagao, 1993). In this way, humans prefer face-to-face because it is the most natural form of communication. Communication that is not face-to-face is less natural and non-face-to-face communication requires more cognitive effort. The more natural a medium, the less individual cognitive effort it will require. **Media naturalness theory** suggests that media that incorporate all the elements of unencumbered face-to-face interaction (e.g., physical presence, ability to see and hear others, synchronicity) will be perceived as more natural for communication. The extent to which a communication medium incorporates actual face-to-face interaction elements defines its degree of naturalness. This suggests that virtual communication may benefit from the inclusion of a broader array of nonverbal communication elements. For example, consider the avatar displaying body movements or using objects to convey nonverbal cues. These actions may affect trustworthiness.

The use of communication technology has the potential to facilitate the development of trust in VTs. However, the development of trust depends on the use of the technology to transmit emotional and nonverbal cues. Along these lines, the greater the number of capabilities used in communication (inclusiveness) to transmit proximity, physical appearance, or nonverbal cues may lead to higher levels of trust.

Embodied Social Presence (ESP) is premised on the notion that the body is the center of communication and an embodied representation, such as an avatar, affects the perceptions of individuals by drawing them into a higher level of cognitive engagement

in their shared activities and communication acts (Mennecke, 2011). People shift their focus between the virtual and real self and between the other social actor's virtual and real self. In VWs, all verbal and nonverbal communication acts and cues are filtered through this embodied representation of the individual. When a user of a virtual environment is presented with a body representing himself or herself in the VW, that representation will have an influence on perceptions of self, identity, and the user's actions associated with that representation (Biocca, 1997). Thus, embodied presence creates an opportunity for the individual to develop and extend his or her identity in the virtual environment and this can help people create an identity for themselves, identify with others, and promote the building of trust. Individuals will also experience a higher level of conveyance of social cues. Conveyance of social cues is a type of presence that relates to the degree to which any given medium as the capacity to transmit information that is perceived by a participant and used in the interpretation of the message (Lombard & Ditton, 1997).

2.7 Summary of Theoretical Foundations

This chapter presented a comprehensive definition of trust. Trust is a multi-dimensional construct and can be broken down into several layers. Each lower layer is dependent on the layer above. This dissertation focuses on individual trust and individual trust can be broken down into two layers – trustfulness and trustworthiness. Individual trust is influenced by one's personality or personality-based trust and one's affiliation with an organization or institution-based trust. VTs have been shown to have high levels of initial trust. These high levels are explained by swift trust theory. However, these

high levels of initial trust are often fragile and dissipate quickly. Additionally, it has been shown that over time, trust in virtual settings will rise to levels that meet or exceed the levels of trust in face-to-face teams (Wilson et al., 2006).

Information technology (IT) is often viewed in terms of capabilities. Capabilities are dynamic - they can change with time through the process of users' adaptation. Adaptation of technology capabilities is determined by how one fits the technology to accomplish a specific task and the capabilities one uses to accomplish a task. What we do not know is how the adaptation of VWTCs will influence trustfulness and trustworthiness in VTs. The literature review and theories presented in this chapter are the baseline or foundation that led to the creation of the conceptual model presented in the next chapter.

CHAPTER 3: CONCEPTUAL MODEL AND RESEARCH PROPOSITIONS

In order to address the research question, *How does the use of virtual world technology capabilities affect the development of trust in virtual teams?,* a conceptual model is proposed. The following section presents this conceptual model as the theoretical foundation that guides the rest of the research, along with key definitions and research propositions.

3.1 Conceptual Model

Figure 3.2 presents the conceptual model for the study. The focus of this study is on the development of trustfulness and trustworthiness in the context of VTs. The dashed line around the diagram represents the boundaries of the study. The diagram also includes references to the theories that inform each part of the model, represented by the name of the theory and a red line drawn to the relevant part of the model. There are four main components within the scope of this study ***trustfulness, trustworthiness, virtual world technology capabilities,*** and ***adaptive use of capabilities.*** The components of the model and the relationship among these components are discussed in the following paragraphs.

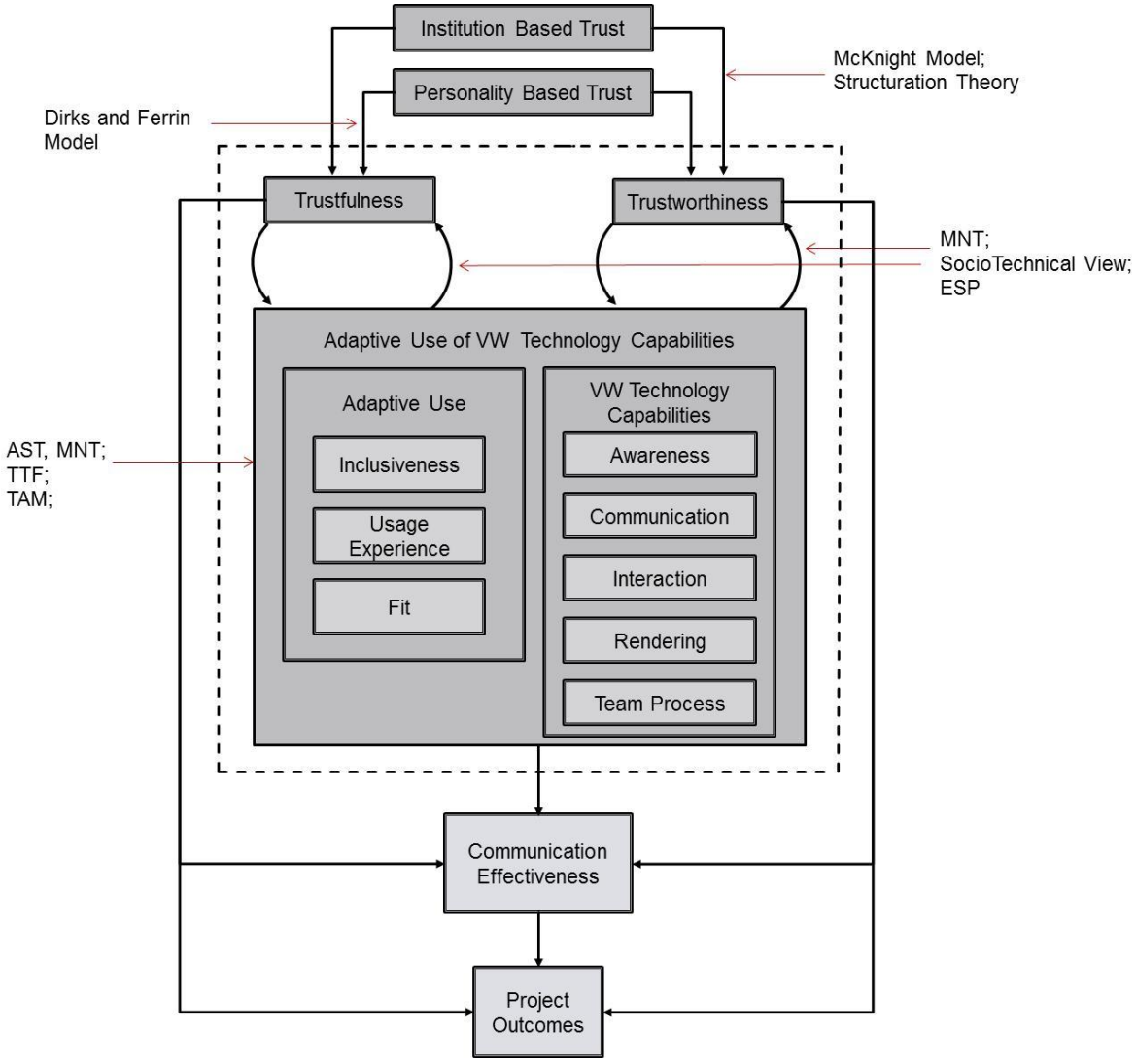


Figure 3.2: Conceptual Model of the Interplay of Trust and VWTCs in VTs

Previous studies have established that trust and communication effectiveness positively affect project outcomes (Jarvenpaa et al., 1998; Jarvenpaa & Leidner, 1999; Cascio, 2000), therefore, project outcomes, communication effectiveness, and the lines connecting these components to the model are outside the boundaries of the study. However, they have been represented in the model to provide a view of the research in

the broader sense. Institution-based trust and personality-based trust are also outside the boundaries of the study and the rationale for their exclusion is discussed below.

3.1.1 Trustfulness and Trustworthiness

Within the context of VTs, trust plays an important role that ultimately affects project outcomes and is positively related to VT effectiveness (e.g. Hakonen & Lipponen, 2009). Trust helps reduce the high levels of uncertainty endemic to the global and technologically based environment (Jarvenpaa & Leidner, 1999) and is one of the keys to the success of VTs. Trust acts as an important aligning mechanism, or glue, that helps build relationships for geographically dispersed workers who spend much of their time working alone in locations removed from other team members and supervisors (O'Hara-Devereaux & Johansen, 1994; Nemiro, 2000). Trust is comprised of two components – trustfulness and trustworthiness. ***Trustfulness***, or trusting intentions, is *one's willingness to depend on another in a given situation and refers to how one trusts other team members.* ***Trustworthiness,*** or trusting belief, is *one's belief that another person is benevolent, competent, honest or predictable in a given situation and refers to how another team member is trusted.* One's trustfulness and trustworthiness is influenced by other types of trust such as personality-based trust and institution-based trust.

3.1.2 Institution-based and Personality-based Trust

Previous research identifies the influence of personality-based trust and institution-based trust on one's individual trust levels (Sarker et al., 2003; Peters & Manz, 2007). These constructs have been included in the model because they affect initial trust levels and are important in the development of individual trust. For example, it is

possible that someone may already have a high level of trust prior to joining the team because of high levels of personality based trust and/or institution-based trust. However, these constructs are outside the boundaries of the study because these types of trust are typically independent of technology and rely on external factors such as one's personality and institutional norms.

3.1.3 Virtual World Technology Capabilities

A ***virtual world*** (VW) *is an instantiation of a metaverse environment that offers a synchronous, persistent network of people, represented as avatars, facilitated by networked computers* (Bell, 2008). VWs offer unique technology capabilities. ***Technology capabilities*** are *distinctive features of a specific technology that include various technological functionalities and offer an undeveloped potential that is dynamic, representing a starting point that can change through interaction in the environment.* (Davis et al, 2009). VW technology capabilities (VWTC) can change dynamically through interaction in the environment (Davis et al., 2009) as people and avatars use the capabilities during a project. These distinctive technology capabilities can be broadly classified into the following five areas (Davis et al., 2009):

- ***Awareness*** capabilities allow users in the world to participate synchronously and provide a sense of being present within the space.
- ***Communication*** capabilities support communication and collaboration through the use of feedback, multiplicity of cues and channels, language variety, channel expansion, and communication support.

- ***Interaction*** capabilities support the process of people and avatars working together with others and engaging with the virtual world environment. Capabilities include real time interaction including interactivity, mobility, and immediacy of artifacts -- an ability to construct visual artifacts in the form of text, images, pictures, three-dimensional pictures, three-dimensional models, or some combination thereof in real time.
- ***Rendering*** capabilities support the process of creating life-like images such as avatars and objects in the virtual world environment. Specific capabilities include personalization and vividness of representation that utilizes 2D and immersive three-dimensional imagery.
- ***Team process*** capabilities support team processes such as process structure, information processing, appropriation support, and socialization/community building.

The foundation for VWTCs draws from various theories (a detailed discussion of the theoretical foundation for these specific capabilities can be found in Davis et al., 2009).

3.1.4 Adaptive Use of Technology Capabilities

Technology is an integral part of work practices and VWs offer unique capabilities. Virtual team members use and adapt VWTCs to support different aspects of communication, coordination, and team process. **Technology adaptation** is the *process by which an individual uses a capability or set of capabilities to perform a specific task and encompasses the inclusiveness, usage experience, and fit of technology in interaction.* Consider an example using VWTCs. VWs offer technology capabilities that

allow individuals to develop various objects or artifacts in the environment. Developing artifacts can help people identify others who are similar to themselves who have similar experience which may be helpful for promoting empathic attitudes that build trust (Hung et al., 2004).

Adaptive use of a capability is the process by which an individual uses or modifies one or more capabilities to perform a task (Burton-Jones & Straub, 2006). Capabilities can be used differently by different individuals. Individuals may use different features of the same system or use capabilities in different ways (Sun & Zhang, 2008). It is the capabilities that are used by a particular individual that define what the system means to them (Sun & Zhang, 2008). Over time, individuals may modify the way capabilities are used. Individuals may use capabilities in a way not only based on vendor specifications, but also in ways that allow them to best complete tasks (Harrison & Datta, 2007). In some cases, individuals adaptively use technology capabilities to find the best fit between tasks and technology.

There are three important conditions relevant to the study of adaptive use of technology capabilities - inclusiveness, usage experience, and fit. First, inclusiveness is an initial condition for adaptation is based on is the extent to which a given technology embraces diverse capabilities (Yu, Owens, Arora, & Khazanchi, 2011). ***Inclusiveness*** *is the extent to which an individual embraces and utilizes the diverse capabilities provided by the technology* (Yu, Owens, Arora, & Khazanchi, 2011). For example, an individual using the various capabilities in a multi-purpose electronic collaboration system would be considered as high inclusiveness. Next, usage experience is relevant in the process of

adaptation. ***Usage experience*** is defined as *the user's experience with using and interacting with technologies* (Yu, et al., 2011). Finally, ***fit*** *is the ideal use of a capability or set of capabilities that affect group performance.* Task-technology fit theory defines fit as "ideal profiles composed of an internally consistent set of task contingencies and GSS elements that affect group performance" (Zigurs & Buckland, 1998). The three primary conditions of adaptive use were chosen based on a review of prior literature on technology adaptation in virtual teams (AST, MNT, TAM, TTF). In order to answer the research question, this research assesses the usage experience, inclusiveness, and fit of VW technology capabilities.

Individuals may vary in the inclusiveness, usage experience and the fit of each of the technology capabilities available in VW technology. The way specific capabilities are adapted has the potential to affect an individual's trustfulness and trustworthiness. The socio-technical aspect of the model supports the relationship between people, technology capabilities, and trust. In the model, the VWTCs represent the technical component and trust represents the social component. These components work together to achieve effective results and the socio-technical perspective guides the analysis to observe emergent behaviors that occur through the use of VWTCs.

3.1.5 Project Outcomes

Project outcomes *are the outputs for the specific project and can be both task-related and team-related outcomes* (McGrath, 1984). Trust is one of the keys to VT success and trust is positively related to project outcomes (Hakonen & Lipponen, 2009). Efficient cooperation is only possible when trust exists among interdependent actors

(McAllister, 1995) and as a result, trust positively affects performance and project outcomes (Cascio, 2000; Jarvenpaa et al., 1998). Empirical tests have found a positive relationship between trust and virtual team effectiveness (Ishaya & Macaulay, 1999; Geister, Konradt, & Hertel, 2006; Corbitt, Gardiner, & Wright, 2004; Edwards & Sridhar, 2005). Prior research has shown that high-trusting teams outperform low-trusting teams (Ishaya & Macaulay, 1999; Geister, et al., 2006) and trust significantly affects the efficiency, effectiveness and quality of virtual team projects (Edwards & Sridhar, 2005).

3.1.6 Communication Effectiveness

Communication effectiveness *is the ability to achieve the desired communication outcome; it is the intended or expected communication effect*. Communication is effective if it achieves the desired outcome. High trusting teams engage in frequent communication, give substantive feedback on fellow members' work, and notify each other of their absences and whereabouts (Jarvenpaa et al., 1998; Hakonen & Lipponen, 2009). Therefore, higher levels of trust can affect communication effectiveness and project outcomes. VWTCs can also potentially enhance communication effectiveness in VTs.

To summarize, the model suggests that the adaptive use of VWTCs has the potential to affect individual trustfulness and trustworthiness in a VT. In VTs, technology is the conduit for communication and coordination as team members conduct work across geographic, temporal, and cultural boundaries. Technology is an integral part of work practices and VWTCs offer capabilities that can interact with trust in teams; however, it is not clear how these capabilities affect trust in VTs.

3.2 Propositions

VWs offer a variety of unique communication methods including visual communication among avatars, video and audio chat, and the communication of deliberate body language, gestures, and other nonverbal cues. VWs foster rich interaction by allowing individuals to perform activities via the mediation of their virtual representations. For example, rendering and interaction capabilities of VWs offer the ability to transmit purposeful nonverbal cues such as those mentioned above. Technology adaptation has the potential to influence the use of VWTCs and it is the adaptation of these capabilities that potentially affect trustfulness and trustworthiness in virtual teams. This leads to the general overarching proposition:

> ***Proposition 1****: The adaptive use of VW technology capabilities affects individual trustfulness and trustworthiness.*

The following proposition is used to address the question *How does the use of virtual world technology capabilities affect the development of trust in virtual teams?*.

> ***Proposition 2:*** *Individual trustfulness and trustworthiness are positively influenced by the adaptive use of specific VWTCs such as awareness, communication, interaction, rendering, and team process.*

3.3 Summary of Conceptual Model and Propositions

The conceptual model presented in this chapter serves as the theoretical foundation that guides the research. The model highlights two main propositions that are examined in this research. This study addresses a gap in prior research regarding the effect of technology on trustfulness and trustworthiness in VTs. The inclusiveness, usage

experience, and fit of VWTCs may enhance the development of trustfulness and trustworthiness in VTs. VWs offer the ability for technology to give the impression that team members are socially and psychologically present during communication situations.

CHAPTER 4: RESEARCH DESIGN

This chapter describes the general research approach used to operationalize the research constructs and describes the research design in more detail. A pilot study was completed prior to the full study and the relevant results from the pilot study are discussed in each of the sections as they inform the overall research method. The pilot study was critical for testing the research design and materials and refining them for the dissertation and data collection.

4.1 Scope of Research

The study focuses specifically on the relationships between the adaptation of VWTCs and trustfulness and the adaptation of VWTCs and trustworthiness. The relationships between personality-based trust, institution-based trust and trustfulness and trustworthiness are excluded from this study. Additionally, the relationship between trustfulness and trustworthiness and project outcomes and communication effectiveness are excluded from this study.

4.2 Research Design

This is a formal study with some degree of exploration. While the research is guided by a specific research question, the study is also exploratory in nature to allow for the identification of additional relationships that may arise by examining the adaptation of VWTCs in VTs.

This study employed a case study design using theoretical replication logic with multiple cases (Yin, 1982; 2003) to collect and analyze data. Multiple groups were used in the study and each group was considered an individual case study. The case study

research approach allowed for contextual analysis and the ability to study specific interrelationships. Replication logic was used to assist in interpreting the findings across cases (Yin, 2012). A replication logic is analogous to that used in multiple experiments to address whether the findings from a set of multiple experiments (cases) support any broader pattern of conclusions (Yin, 2012). The result of the multiple case approach is the support and enrichment of a rich theoretical framework and serves to generate knowledge (Yin, 1982). The approach was used to generate knowledge and answer the research question.

The study relied on quantitative research methods to measure trustfulness, trustworthiness and adaptive use of VWTCs, while qualitative data was used for to supplement conclusions and provide further explanation of the findings. The qualitative data was also used to illustrate the conceptual model as described in Chapter 6. This approach has been used previously to explore a research framework of VWs (Owens et al., 2011). The combined qualitative and quantitative approach allows for careful review of combined data sources to identify patterns and offer explanations to help improve understanding of key features of the model (Owens et al., 2011).

Teams composed of individuals with varying skills and backgrounds conducted a project in Second Life that required them to interact and create a Rube Goldberg machine within a two week time period. Participants were encouraged to use all of the technology capabilities available within Second Life and were told that Second Life was the preferred communication medium. Email was used only to confirm participants and meeting times.

The task and instructions were the same for all teams. Data was collected regarding technology use, team member interaction, and levels of trustfulness and trustworthiness via questionnaires, video, text chat log transcripts, and screen captures.

4.3 Research Setting, Tasks, and Participants

4.3.1 Research Setting

Second Life was used as the VW technology for the study, chosen for its stability and maturity as a three-dimensional VW environment. In Second Life, avatars interact in workspaces called islands. Project teams met on the UNO Island[2] in a sandbox area where they were able to collaborate on assigned tasks. A sandbox is a place for creativity and it is a dedicated space in which avatars can build objects freely. Participants were required to meet in-world and were free to utilize any of the available technology capabilities throughout the project.

4.3.2 Task

Participants were assigned the task of working together in Second Life to construct a three-dimensional Rube Goldberg machine. Rube Goldberg machines are complex, highly over-engineered contraptions that perform a simple activity (Merriam Webster, 2012). This task was chosen for several reasons. First, the task was complex enough to require that participants utilize all of the technology capabilities afforded by Second Life. Second, the task's complexity was expected to require team members to work together, interact extensively, and rely on each other to complete the project, therefore, requiring team members to develop trust in the other individuals. Third,

[2] SLURL (second life URL): http://slurl.com/secondlife/CIST%20Nebraska%20Omaha/131/26/37

designing and building a Rube Goldberg machine requires creativity and provides an opportunity to observe how participants use the features and capabilities of the VW. Finally, this particular task was used during a prior research study and proved to be successful in the aforementioned areas (see Owens et al., 2011).

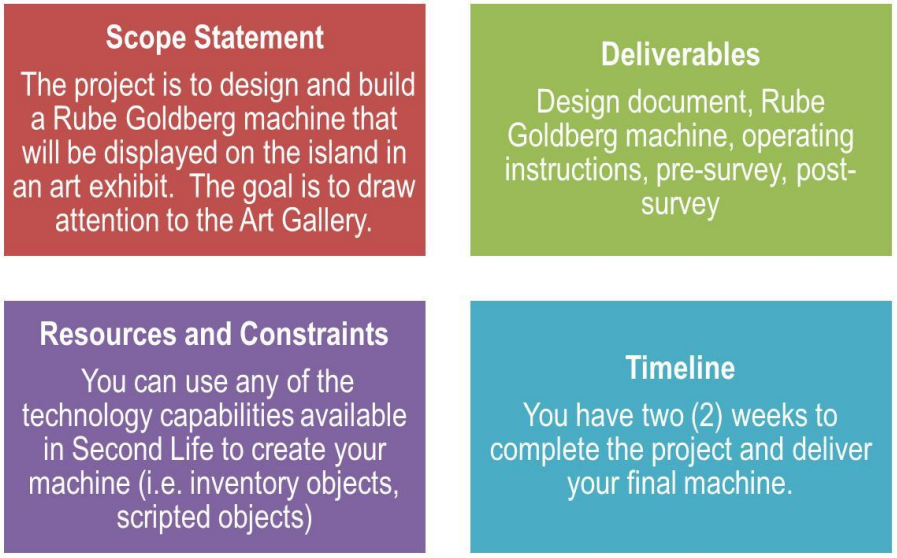
Participants were each given a unique project requirement explaining the requirements for the Rube Goldberg machine. Participants had to share their requirements with others in the team in order to determine an overall design. The unique project requirement was passed to each individual using a notecard in Second Life. A notecard is considered a communication capability and is an object containing text that can be shared between individuals. The four project requirements are outlined in the following table.

Table 4.8. Requirements for the Rube Goldberg Machine

Requirement 1	Your machine must have at least three (3) different components or stops.
Requirement 2	Your machine must have at least three (3) different colors or textures.
Requirement 3	Your machine must contain at least one (1) circular object and one (1) rectangle.
Requirement 4	Your machine should have the ability to be started and stopped by an observer or avatar.

Each team had two weeks to complete the project so that trustfulness and trustworthiness could be measured over time. During an initial meeting, participants were directed to a billboard outlining the scope statement, deliverables, resources and constraints, and timeline for the project. Figure 4.3 shows the billboard that was displayed on the island during the project.

Figure 4.3. Project Overview



The pilot study revealed the importance of identifying an appropriate task in the overall context of the research study. Previous studies have identified the nature of a group's task as a variable which plays an important role in group performance (Hackman & Morris, 1975; Poole, Siebold, & McPhee, 1985; Shaw, 1981). The group task is an important variable that can account for as much as 50 percent of the variance in group performance (Poole et al., 1985).

During the pilot, participants were given a small task that was part of a larger project. The task was to develop a project charter based on a given scenario. The pilot revealed that the task was not complex enough and did not offer participants the ability to use the various technology capabilities available to them. Participants relied heavily on text chat to complete the task. As such, the task did not require participants to use any of the other technology capabilities available to them such as interaction or rendering

capabilities. In order to examine the adaptive use of various VWTCs, the task needed to require participants to utilize objects available to them in the three dimensional environment. As one participant pointed out, Second Life is not suited for all task types, for example, having a student attend a lecture in Second Life would not be the most effective use of the technology. After careful review of the pilot data and prior literature, it was determined that participants needed to build something together. Second Life is a three-dimensional world created entirely by its participants and building a machine would not be out of character for those individuals who frequent Second Life. Based on this fact, the task was modified to include a series of steps that required participants to use a broader range of capabilities in Second Life.

The task used in the study can be classified as both an intellective task and preference task. Each member of the group was given a part of the information necessary for carrying out the task, which made it necessary to exchange information and complete the project. Intellective tasks require members to combine their individual efforts and contributions to arrive at the best solution for a given problem or task (Zornoza, Ripoll, & Peiro, 2002). Preference task types use judgments or preferences where there is no correct answer. Because of this, social interaction of group members is important so that different viewpoints are heard and all members can participate (Huang & Wei, 2000). Preference tasks are based on personal preferences and require individuals to develop an opinion and negotiate for their point of view. The task was designed to require individuals to work together in such a way that would affect their trustfulness and

trustworthiness of others. This project was broken down into four deliverables or steps. The following table provides the details of each step.

Table 4.9. Description of Steps

Steps	Description
Step 1 – Meet and Greet	Your first task is to meet your team members and the project sponsor. You are required to participate in a 30 minute team meeting where you will be introduced to everyone. You will also be provided with additional instructions necessary to complete the project – the project scope statement and required deliverables.
Step 2 – Machine Design	You will be working as a team and together your team's task is to design and build a "Rube Goldberg" machine. Each of you has received a note with additional specifications for your machine. After you have compared notes with each other, you will be able to determine the overall design specifications. Your task is to create a design document for your machine. A design document provides details and specifications for the machine and is typically used by the developers. You are to deliver a single document that describes the design of your machine. A well-written design document is a powerful tool and can keep the team pointed at the goals and requirements established at the start of the project. A good design document should include a description of the various components and may even include a diagram of the machine. The next step is to schedule a meeting to build the machine.
Step 3 – Build Machine	Your team's task is to build the "Rube Goldberg" machine according to the design specifications. The final step in the project is to provide the operating instructions and complete the survey.
Step 4 – Operating Instructions	Your final task is to provide operating instructions. These instructions can be in whatever form you choose. They should be available next to the machine so that visitors know how to operate the machine. Once you have completed the instructions each of you is required to complete the survey and send it to the project sponsor.

4.3.3 Participants

Prior to soliciting participants for the study, IRB approval was obtained for the research design (see Appendix C). Participants were recruited from within Second Life, first through personal contacts and established educator and developer interest groups. Second Life residents were also contacted using notecards by visiting various locations in Second Life and providing information about the research study. This method was useful

during the pilot and proved to be successful in recruiting participants with Second Life experience. All of the participants were familiar with Second Life and were experienced users; they did not require training and did not experience a learning curve when participating in the collaborative meetings.

Due to the synchronous nature of the task, participants were required to meet at the same time, even though they were distributed across various time zones. Participants had no prior history working with one another. They were motivated to participate in the project because they were interested in studies of Second Life and they received monetary compensation for their time (6,200 Linden dollars, which is the equivalent of $25 USD).

The author served as the project sponsor and was available during all sessions to answer questions and observe. Teams were formed sequentially throughout the project, as one team finished the next team began. The following table provides information about the teams used in the study and when they started and completed their projects.

Table 4.10. Total Participants in Each Team

Team #	Total Participants	Start Date	Completion Date
1	2	11/8/2011	11/23/2011
2	4	12/1/2012	12/9/2012
3	5	12/7/2012	12/19/2012
4	3	1/26/2012	2/9/2012
5	3	2/12/2012	2/24/2012
6	4	4/9/2012	4/23/2012
7	4	4/11/2012	4/23/2012
Total	25		

Demographic information was collected from individuals during the pre-survey. The following tables and graphs provide information about the characteristics of individuals in each group.

Figure 4.4. Gender of Participants

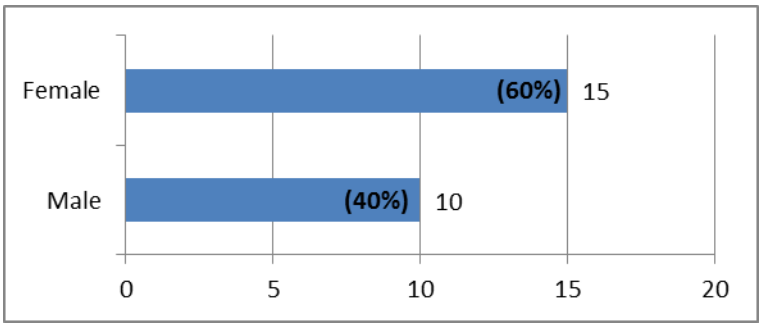
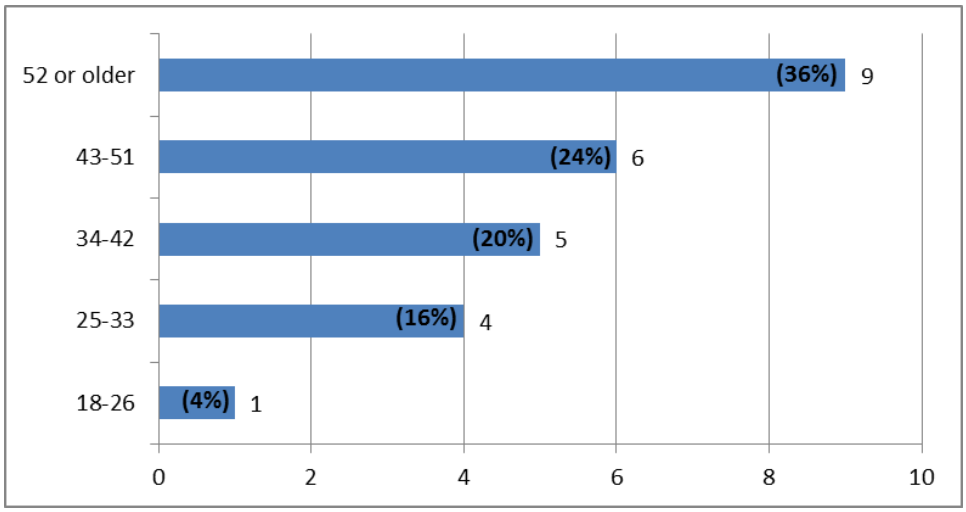


Figure 4.5. Age of Participants



Over 50% of the participants were over 40 with 36% of participants being 52 or older. This was unexpected given the immersive nature of the technology. It was expected that younger participants (25-33) would participate in the study because of the

complexity and newness of the technology. Specific demographic information for each group is provided in the following table.

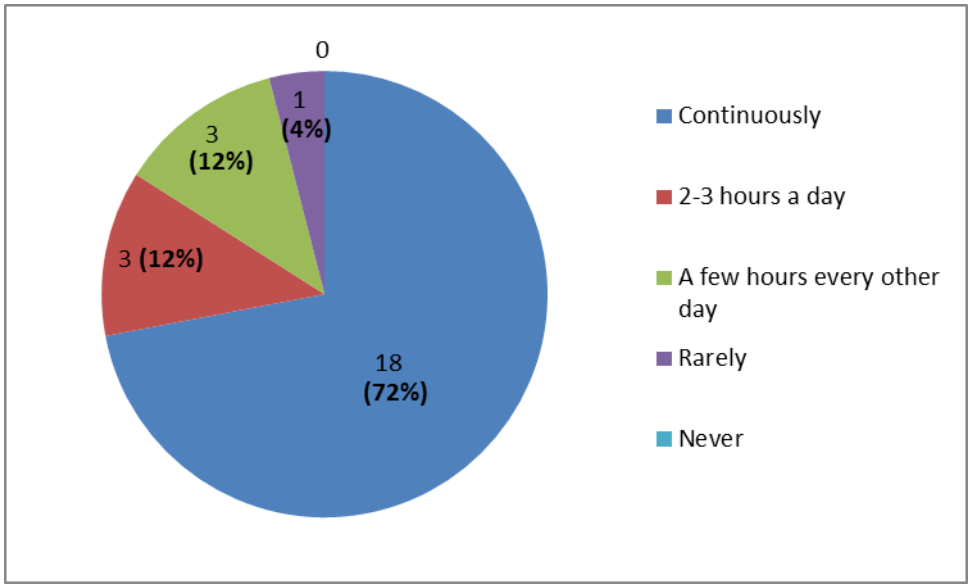
Table 4.11. Demographics by Group

	Gender	Age
Group 1 2 participants	F	25-33
	F	43-51
Group 2 4 participants	M	52 or older
	F	25-33
	F	52 or older
	M	52 or older
Group 3 5 participants	F	43-51
	F	52 or older
	M	52 or older
	F	25-33
	F	43-51
Group 4 3 participants	M	34-42
	M	43-51
	F	52 or older
Group 5 3 participants	M	34-42
	F	34-42
	F	52 or older
Group 6 4 participants	M	18-26
	M	25-33
	M	43-51
	F	52 or older
Group 7 4 participants	M	52 or older
	F	34-42
	F	34-42
	F	43-51

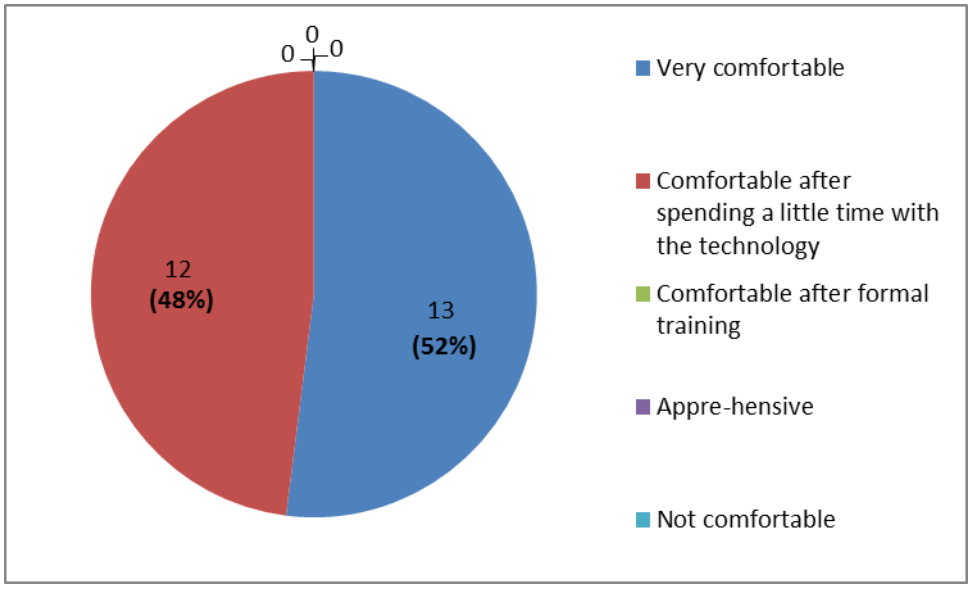
Additional information was collected about participant experience and comfort level with technology. The following figures provide data about questions asked in this regard.

Figure 4.6. Awareness of Technology Capabilities

How often do you use technology to complete tasks in your daily job?



Describe your comfort level with new technology.



Participants were either very comfortable or comfortable after spending a little time with the technology. Additionally, most of the participants used technology continuously every day. Participants in the study appeared to have a high comfort level with Second Life and were familiar the capabilities provided by the VW.

4.4 Technology

Second Life was used as the VW for the project. The technology had to allow for objects to be stored and retrieved at a later date. This was necessary for each team's machine to persist in the space throughout the duration of the project. The technology also had to allow the ability to monitor team work. This was necessary for research purposes. Part of the research was to observe how technology is adapted. Similarly, the researcher needed access to the objects to ensure the machines met the requirements.

All team meetings took place within Second Life. Email was used for initial communication to coordinate the first meeting. Subsequent communication took place using Second Life. No other technology was used. Table 4.12 shows the various capabilities available within Second Life and illustrates how they map to the specific technology capabilities noted in this research.

Table 4.12. Second Life Technology Capabilities

Virtual World Technology Capability	Second Life Capabilities
Awareness	Avatar presence Instant messaging (text chat)
Communication	Instant messaging (text chat) Voice chat Notecards Gestures (non-verbal communication) Avatar presence (non-verbal communication) Animations (non-verbal communication)
Interaction	Interactivity through building and scripting Avatar mobility Object mobility
Rendering	Avatar presence Building and scripting Object rendering
Team process	Community building using groups and islands

4.5 Data Collection and Measurement

The study explores the relationship between the adaptive use of VW technology capabilities and the development of trustfulness and trustworthiness. In that regard, the following constructs were used: usage experience, inclusiveness, fit, trustfulness and trustworthiness.

Data was collected from multiple sources in order to enable a rich understanding and triangulation of the data. Measures were captured from a variety of sources including surveys, video, built artifacts, still images, and text chat. Multiple data sources provided opportunities for triangulation and the unique synthesis of different measures. Analysis of the data occurred within each case and across cases and included the sources of data listed in the table below.

Table 4.13. Sources of Data

Data Source	Description
Survey	Pre-project and post-project surveys
Text Chat Logs	Text capture of dialogue among subjects using instant messages or notecards. Recorded in text chat log file and transcribed to Excel spreadsheet for coding.
Video and Still Images	Full-motion continuous images of individual performance and team interactions while working in Second Life. Screen captures of individuals and teams at various points during their project. Captured via systems video recorder.
Observation Notes	Written notes recorded by the researcher at the end of each team's session, with observations about specific interactions or events.

4.5.1 Quantitative Data Collection

Quantitative data was collected using two questionnaires - (1) pre-project survey and (2) post-project survey. Table 4.14 shows how each construct for the study was measured. The pre-project questionnaire asked participants questions about their perceptions of the upcoming project. The post-project questionnaire asked participants questions about their experience working on the project. Appendix D includes the pre-project and post-project surveys used for the study.

One of the challenges was identifying appropriate measures for trustfulness and trustworthiness. Although various studies have measured trust, there are often inconsistencies in the measures used. Prior studies on trust have used measures for trustfulness and trustworthiness interchangeably. For example, Hakonen and Liponen (2009) employed an overall measure of trust using measures for integrity, benevolence and interpersonal trust. Integrity and benevolence are indicators of trustworthiness; however, the study did not differentiate between trust and trustworthiness. In another study by Zolin et al., 2004, interpersonal trust was measured using measures for propensity to trust and trustworthiness. While measures of trustworthiness were used to

measure interpersonal trust, there was no discussion about trustworthiness and its relations to trust in the study.

For this study, separate measures for trustfulness and trustworthiness were used in order to accurately measure these different dimensions. Table 4.14 offers the conceptual definition, operational definition, and scoring of each concept.

Table 4.14. Trustfulness and Trustworthiness Measurement

Concept	Conceptual Definition	Operational Definition	Scoring (Measurement)
Trustfulness	Trusting intentions One's belief about another's motives or willingness to depend on another in a given situation. Trustfulness has cognitive and affective foundations.	The intent to trust another based on 9 items measuring affective and cognitive dimensions.	Mean of items In order to get a team trust score, collapse the responses of various team members into a single team score by averaging the responses of the individual members on each team. (Jarvenpaa, et al., 1998). Measures were adapted from four different instruments in order to account for both the affective and cognitive dimensions of trustfulness.
Trustworthiness	Trusting belief One's belief that another person is benevolent, competent, honest or predictable in a situation. How an individual is trusted by other team members.	The belief that another can be trusted based on 6 items.	Mean of items In order to get a team trust score, collapse the responses of various team members into a single team score by averaging the responses of the individual members on each team. (Jarvenpaa, et al., 1998).

Survey data was also used to measure the adaptive use of VWTCs. Table 4.15 provides the conceptual definitions, operational definitions, and scoring for each concept.

Table 4.15. Adaptive Use of VWTC Measurement

Concept	Conceptual Definition	Operational Definition	Scoring (Measurement)
Adaptive Use of VWTC	The way in which an individual uses and/or modifies capabilities to perform a task and the individual perception about how those capabilities affected their performance.	Measured by usage experience, inclusiveness, and fit.	Not measured separately - measured by the combine means of usage experience, inclusiveness, and fit.
Usage Experience	Individual perception about one's experience in terms of performance, productivity, effectiveness, and overall usefulness from using technology capabilities to meet their task needs.	Individual perception about one's experience with the technology capabilities based on 4 items.	Mean of items
Inclusiveness	The extent to which technology capabilities are utilized to accomplish a task, which may include combining some capabilities with others. (Definition based on McKnight's (2005) definition of functionality - The degree to which the technology will have the capabilities needed to accomplish one's task). One's perception about what capabilities were used.	The extent to which the capabilities of a given technology are utilized to complete a task based on 4 items.	Mean of items
Fit	The way in which users repurpose or substitute technology capabilities to complete a task. One's perception about how capabilities are used.	The way in which users repurpose or substitute capabilities to complete a task based on 7 items.	Mean of items

A list of each survey item, source, and associated concept is provided in the following table.

Table 4.16. Pre and Post Survey Items and Source

Concept	Coding	Survey Item (Pre and Post)	Source
Trustfulness	TF1 Affect-based	I believe we will have a sharing relationship on the team; we will be able to share our ideas and feelings. We have a sharing relationship on the team, we can share our ideas and feelings	McAllister, 1995
	TF2 Affect-based	I will be able to talk freely to the team about difficulties with the project; I know they will listen. I can talk freely to the team about difficulties with the project and I know they will listen.	McAllister, 1995
	TF3 Affect-based	If I share my problems with the team, I know they will respond constructively and caringly. If I shared my problems with the team, I know they would respond constructively and caringly.	McAllister, 1995
	TF4 Cognitive-based	Other team members will approach the project with professionalism and dedication. Other team members approach the project with professionalism and dedication.	McAllister, 1995
	TF5 Cognitive-based	I can rely on the team not to make the project more difficult by careless work. I can rely on the team not to make the project more difficult by careless work.	McAllister, 1995
	TF6 Cognitive-based	If I have my way, I won't let other team members have influence over issues that are important to the project. If I had my way, I wouldn't let other team members have influence over issues that are important to the project.	Mayer & Davis, 1999
	TF7	I feel comfortable depending on my team for the completion of the project. I feel comfortable depending on my team for the completion of the project.	Jarvenpaa et al., 2004
	TF8	I feel that my team members will be honest with me. I feel that my team members are honest with me.	Cummings & Bromily, 1996
	TF9	I am comfortable letting other team members take responsibility for tasks which are critical to the project even if I cannot monitor them. I am comfortable letting other team members take responsibility for tasks which are critical to the project even when I cannot monitor them.	Jarvenpaa et al., 2004
Trustworthiness	TW1 Integrity	Members of my team will show a great deal of integrity. Members of my team show a great deal of integrity.	Jarvenpaa et al., 1998
	TW2 Integrity	I will be able to rely on those with whom I work with in this team. I can rely on those with whom I work with in this team.	Jarvenpaa et al., 1998

Concept	Coding	Survey Item (Pre and Post)	Source
	TW3	Overall the people in my team will be trustworthy. Overall the people in my team are trustworthy.	Jarvenpaa et al., 1998
	TW4 Benevolence	We will be considerate of one another's feelings in this team. We are usually considerate of one another's feelings in this team.	Jarvenpaa et al., 1998
	TW5 Benevolence	The people in my team will be friendly during the project. The people in my team were friendly during the project.	Jarvenpaa et al., 1998
	TW6 Ability	We will have confidence in one another in this team. We have confidence in one another in this team.	Jarvenpaa et al., 1998
Usage Experience	UE1	Using the capabilities provided by the technology will improve my performance. Using the capabilities provided by the technology improved my performance.	Bhattacherjee & Premkumar, 2004; Davis et al., 1989.
	UE2	Using the capabilities provided by the technology will increase my productivity. Using the capabilities provided by the technology increased my productivity.	Bhattacherjee & Premkumar, 2004; Davis et al., 1989.
	UE3	Using the capabilities provided by the technology will enhance my effectiveness. Using the capabilities provided by the technology enhanced my effectiveness.	Bhattacherjee & Premkumar, 2004; Davis et al., 1989.
	UE4	Considering all tasks, the capabilities will be useful for in completing this project. Considering all tasks, the capabilities were useful for in completing this project.	Bhattacherjee & Premkumar, 2004; Davis et al., 1989.
Inclusiveness	IN1	The technology will have the capabilities required for our tasks. The technology had the capabilities required for our tasks.	Lankton & McKnight, 2006
	IN2	The technology will have the overall capabilities I need. The technology had the overall capabilities I needed.	Lankton & McKnight
	IN3	I will use some capabilities together for the first time. I used some capabilities together for the first time.	Sun & Fricke 2009
	IN4	I will combine capabilities with other capabilities to finish a task. I combined capabilities with capabilities to finish a task.	Sun & Frike 2009
Fit	FT1	I will not hesitate to use a capability because it is favored over the one I am using. I did not hesitate to use a capability because it was favored over the one I was using.	Sun & Frike 2009
	FT2	I may apply some capabilities to tasks that the capabilities were not meant for. I applied some capabilities to tasks that the capabilities were not meant for.	Sun & Frike 2009
	FT3	I may use capabilities in ways that were not intended to be used. I used some capabilities in ways that were not intended	Sun & Frike 2009

Concept	Coding	Survey Item (Pre and Post)	Source
		to be used.	
	FT4	The developers of the technology will probably disagree with how I will use certain capabilities. The developers of the technology would probably disagree with how I used certain capabilities.	Sun & Frike 2009
	FT5	I may use some capabilities in a way at odds with its original intent. I used some capabilities in a way at odds with its original intent.	Sun & Frike 2009
	FT6	I may invent new ways of using some of the capabilities to complete a task. I invented new ways of using some of the capabilities to complete a task.	Sun & Frike 2009
	FT7	I may create work arounds to overcome system restrictions. I created work arounds to overcome system restrictions.	Sun & Frike 2009

4.5.2 Qualitative Data Collection

For each group meeting, a text chat log, video, associated still images, and an observation log was saved and stored for later analysis. All group meetings took place in Second Life. Each group meeting was recorded using video recording software. Still images were also captured throughout the project highlighting specific interactions among group members. Communication during each group meeting took place using the text chat feature in Second Life. All text chat is stored in a log file that was used as one of the data measurements. At the end of each group meeting, an observation log was created that documented specific interactions between individuals, specific uses of the technology, and specific comments made by individuals. The qualitative data was used for triangulation and to supplement conclusions and provide further explanation of the findings. The qualitative data was also used to illustrate the conceptual model.

There are several strengths of qualitative data. Qualitative data are particularly useful for supplementing, explaining, or illuminating quantitative data gathered from the

same setting (Miles & Huberman, 1994). Qualitative data focus on naturally occurring, ordinary events in natural settings (Miles & Huberman, 1994). The emphasis is based on a specific case and the influences of the local context are not stripped away but are taken into account. Another feature of qualitative data is their richness and holism (Miles & Huberman, 1994). Qualitative data provide vivid descriptions nested in a real context. Qualitative data are typically collected over a sustained period which makes them powerful for studying a process (Miles & Huberman, 1994).

4.6 Case Study Setup and Procedures

Each team completed their project at different times. The timing of the first team took place based on lessons learned from the pilot study. The pilot revealed the importance of task design and communication of clear requirements with regard to expectations and deliverables. A summary of the lessons learned from the pilot are included in Table 4.17. The remaining teams completed their projects as participants became available with the goal of having no more than two teams running at the same time so that the researcher could participate in all meetings.

Table 4.17. Findings from the Pilot Study

Pilot Study	Findings	Changes to Research Design
Task Create a project charter document as a team.	The task was not complex enough and did not offer participants the ability to use the various technology capabilities.	The task was modified to include a more complex task. The task included a series of steps that required participants to use a broader range of VWTCs.
Participants Second Life residents were contacted using notecards by visiting various locations in Second Life and providing information about the research study.	This method was useful during the pilot and proved to be successful in recruiting participants with Second Life experience.	No changes were made.
Timing of groups Groups were run in parallel.	This method was difficult to observe all the group interaction.	Groups were run in parallel with the goal of having no more than two teams running at the same time so the researcher could participate in all meetings.
Participants were provided with high level expectations of creating a project charter, with no clear expectations about timelines, constraints, or resources.	The teams needed clear requirements with regard to deliverables, timeline, resources, and constraints.	Specific project requirements were communicated to participants during Step 1 – Meet and Greet and these requirements were also displayed on billboards in the sandbox area.
There was a plethora of data available for each group meeting.	Organizing and making sense of large amounts of data for later analysis was challenging.	A plan for collecting and organizing the data was created which included the creation of an observation log at the end of each group meeting that documented specific interactions between individuals, specific uses of the technology, and specific comments made by individuals.

Participants were recruited from within Second Life using notecards, text chat and email. Second Life residents who showed interest in the study were sent an email with more information about the project. Those who were interested in participating were sent another email with information describing the first step in the project. The initial email that was sent to participants is included below.

Thank you very much for your interest in my research study. I am hoping that your participation and feedback will help lead to advancements in the use of virtual worlds to solve first world project management challenges.

I have attached a document that will provide you with detailed information for the project. There are four tasks in the project. The first task is to complete following:

- Review the Project Overview document (included as an attachment)
- Complete Step 1 of the project (details provided below, time commitment ~30 minutes)
- Complete the pre-project survey available at the following link -

http://www.surveymonkey.com/s/XRBJJQR (time commitment ~10 minutes)

Step 1 – Meet and Greet: Your first task is to meet your team members and the project sponsor (myself). You are asked to participate in a 30 minute team meeting where you will be introduced to everyone. During the meeting you will be provided with the project scope statement and required deliverables. The total time commitment for the first task is about 30 minutes.

We will need to agree on a time to meet. I have setup a poll using Doodle calendar. Please visit the following link http://www.doodle.com/z68qf773tzgizenb and choose all times that you would be available for a 30 minute meeting in Second Life. You can use the drop down list box at the top to change the times to match your time zone. Feel free to use the comments section to provide details about times that are most convenient for you. I will do my best to accommodate everyone's schedule. If you don't find a time that works for you that is okay, just send me a note or edit the comments letting me know what days/times work best for you.

I am very interested in your feedback throughout the process. I look forward to working with everyone and thank you again for your time.

Dawn Owens

Prior to their first step, participants were asked to complete the pre-survey and also fill out their availability for meetings using Doodle Calendar[3], a free calendar tool that allows the creation of a meeting poll that can be updated by participants using the required link. Participants were also provided a link to the project meeting area with the following

[3] http://www.doodle.com/

information - "You can teleport to the 'CIST Omaha Island' where all the project activities will take place. Feel free to tour it on your own and find the Sandbox area where we will be working."

Once the first meeting time was determined, participants were notified of the time and reminded of the location. The first meeting satisfied the requirements for Step 1 – Meet and Greet. Participants had an opportunity to meet the other members of their team and participants were also provided details about the remaining steps and requirements. Many of the participants had visited the island prior to the first meeting and already had an understanding of the project requirements.

Before the end of the first session, all agreed on a meeting time to complete Step 2 – Design the Machine. At the end of the session, the text chat log files, video, still images, and observation log were stored for later reference. This same process took place for Steps 2, 3, and 4.

Upon completion of Step 4, participants were required to complete the post-project survey. A link to the survey was provided either via notecard or email as preferred by the participants. Once it had been confirmed that the participant completed the survey, the participant was then paid the appropriate Linden dollars for their participation in the project.

4.7 Statistical and Data Analysis Methods

For this study, a multi-method design using both quantitative and qualitative data was used. Various scales and measures were taken from previous research to evaluate the research propositions from a quantitative perspective. From a qualitative perspective,

a triangulation approach was used to analyze the data by examining the content of text chat logs while simultaneously considering individual actions and team interactions as portrayed in video and still images and the observation logs. Additionally, the qualitative data was examined in relation to the quantitative data in order to triangulate the data in a true sense (true triangulation of data is supported by more than one source of evidence [e.g. Sieber, 1973; Yin, 1982]). Synthesized observations were evaluated in light of participants' comments and perceptions from the survey and to develop a holistic assessment of the findings. Analysis involved a careful review of the combined data sources to identify patterns and offer explanations. The following table describes the validity tests for the research (adapted from Yin, 2009, pp. 40-45).

Table 4.18. Validity Tests for Research (Yin, 2009)

Validity	Description	Stage of Research
External validity	Replication logic in multiple case studies	Research design
Construct validity	Multiple measures of trust Multiple sources of evidence and chain of evidence	Data collection
Reliability	Case study protocol	Data collection
Internal validity	Random selection Pattern matching, explanation building,	Research Design Data analysis

To assure that the research had construct validity, it was important to measure each construct in more than one way (Judd, Smith, & Kidder, 1991). The constructs in the study were measured both quantitatively and qualitatively using multiple sources of evidence.

In order to increase internal validity and reduce selection threat, participants for the study were recruited arbitrarily in Second Life and placed into groups at random. The random process used to select participants also enhanced the external validity of the

study. Additionally, replication logic with multiple cases was used to enhance external validity. Research as replication with other groups is an important part of maximizing external validity (Judd et al., 1991; Yin, 2009).

Video and still images were used to observe how team members interacted with each other during the project. The goal was to obtain information about how avatars used the technology to interact, communicate, and manage the project. For example, still images revealed that avatars used actual objects to explain their ideas for the Rube Goldberg machine design. When analyzing the video and still images, the following questions were considered – 1) How did people represent themselves in interactions? 2) How did people utilize the technology to convey trustworthiness? 3) How did people utilize the technology capabilities to convey trustfulness? 4) How were the technology capabilities used in group interactions?

The text chat log was analyzed to determine frequency of communication and to identify patterns of discussion. For example, during Step 1, people would use the text chat log to determine whether someone was a builder or a scripter. In many cases, people were either one or the other and rarely possessed both skills.

Pattern matching was used to increase internal validity. Pattern matching helped identify specific outcomes in each case that related to the research model. Explanation building was used to analyze the case data to build an explanation about the actions of each team (Yin, 2003).

Replication logic was applied in interpreting the findings across the multiple cases. Each group was considered a case and each group completed the project

sequentially rather than simultaneously. Each group completed the project using the same research procedures, no changes were made to the research design. An observation log was updated at the end of each meeting which documented specific interactions between individuals, specific uses of the technology and specific comments made by individuals. These observations were helpful in answering questions when observing additional groups interact. As an example, it was noted that avatar appearance was very important in Group 2. Would this also be important in subsequent groups?

4.8 Summary of Research Design

This chapter presented the detailed research design including the influences from the pilot study. This study employed a case study research design using multiple methods for data collection and multiple cases. The following chapter presents the findings and analysis of the results of the study.

CHAPTER 5: ANALYSIS OF RESULTS

This chapter presents the results of this study. A descriptive analysis of the projects is presented first followed by a discussion of the results of the qualitative and quantitative analysis in relation to the research propositions.

5.1 Descriptive Analysis of Projects

Within this section, a descriptive overview of how the teams worked together to complete their projects is presented. This overview provides the context for the subsequent discussion of the specific research findings. The following table provides a summary of the project outcome for each team that participated in the study.

Table 5.19. Summary of Projects

Team #	Rube Goldberg Machine Description	Project Result
1	4 components Ball rolls down a ramp and hits a domino. Dominoes fall and move a bar which raises a flag up the flagpole.	Met all requirements
2	6 components Avatar runs in a wheel which generates a spark of electricity which drops a ball down a compartment. The ball hits a domino. Dominoes fall and close a switch which lights a Christmas tree.	Met all requirements
3	6 components A cannon shoots a ball into the air and it lands on a platform. The ball rolls down the platform and hits a rock with a flower. Atop the flower is a bee. The Bee starts buzzing and moves a ball down a ramp which hits a boot. The boot hits a toaster which pops out a piece of toast.	Met all requirements
4	3 components A door opens which hits a domino. Dominoes fall and hit a lamp. In the process of hitting the lamp, the lamp illuminates.	Met all requirements
5	4 components A palm tree drops a coconut. A surf board raises and lowers. A balloon inflates and pops sending particles in the air.	Did not meet all requirements because the machine did not have a continuous chain of events after the initial interaction. Each component in the design had to be touched by the avatar in order to cause an action.
6	6 components An avatar sits on a bicycle and pedals. The pedals start a windmill and the windmill blows a mannequin. The mannequin moves another mannequin which starts a dog running around in a circle. The dog knocks over a pail of water which causes a flower to grow out of the ground.	Met all requirements
7	6 components A ball rolls into a pyramid and shoots out the top of the pyramid. The ball shoots in the air to a ramp and rolls down the ramp and hits a windmill. The windmill begins turning and hits a domino. Dominoes fall and hit a panda bear. The panda bear throws the ball into a basketball hoop.	Did not meet all requirements because the machine did not have a continuous chain of events after the initial interaction. Each component in the design had to be touched by the avatar in order to cause an action.

Each team participated in a total of four steps and each step required a synchronous meeting. The first meeting satisfied the requirements for Step 1 – "Meet and Greet." The purpose of the meeting was to meet each of the members in a team.

Prior to the meeting, participants were given a link to the meeting location along with the following information –

> *"You can teleport to the 'CIST Omaha Island' where all the project activities will take place. Feel free to tour it on your own and find the Sandbox area where we will be working."*

The meeting location contained billboards and signs describing the project scope, deliverables, and timeline (Figure 5.7).

Figure 5.7. Project Billboards in Second Life

During the first meeting, each team was provided with the project scope statement (build a Rube Goldberg machine) and required deliverables to complete the project (complete steps 1-4 and complete the pre and post survey). Many of the participants visited the location prior to the first meeting and were aware of the project requirements upon coming to the meeting.

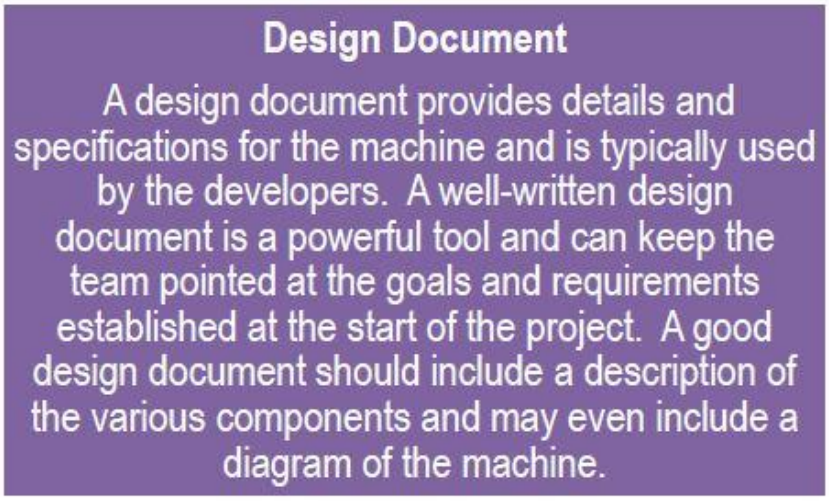
At the "Meet and Greet", participants would introduce themselves and explain their skills in relation to building or scripting in Second Life. Second Life has its own scripting language (Linden Scripting Language or LSL) and this scripting language is used to add life to objects. Scripting can be added to objects to make them move, change

colors, change size, etc. As the project sponsor, I provided an opportunity for participants to ask questions. As a group, we would also agree on a time to complete Step 2 – "Machine Design". The initial meetings were relatively short (30-40 minutes) and many of the participants would hurry off after the meeting. However, in subsequent meetings, avatars would stay around after the meeting and communicate about various topics. This collaborative behavior is described in the forthcoming paragraphs.

At the second meeting, many of the participants came prepared to discuss their ideas for the Rube Goldberg machine. Each team was tasked with creating a design document for their machine. Each participant in the team received a notecard with a unique specification for the machine (refer to Table 4.8). Participants were encouraged to share their unique requirement with the others on the team. In some groups, one took the responsibility of compiling all of the requirements into a single notecard and then shared that notecard with all in the team so each participant would have a complete list of the requirements.

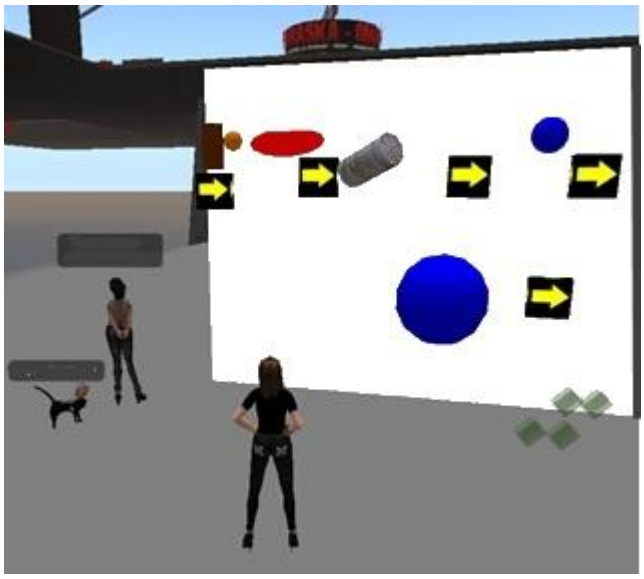
Participants were instructed to create a design document. They were not provided with detailed information about the process of creating a design document other than a definition of a design document – which was displayed on one of the project billboards (Figure 5.8).

Figure 5.8. Design Document Instructions



As such, each team submitted a different form of a design document using the technology capabilities within Second Life to present the document. For example, one team delivered a formal design document in PDF form while another delivered a diagram via an image displayed on an in-world object. Another team used the technology capabilities to build a white board and posted objects onto the whiteboard to represent their machine design (see Figure 5.9) and yet another built a mini-model of their design.

Figure 5.9. Whiteboard used to Display Machine Design



Once the meeting ended, participants were less anxious to hurry off. After completing the meeting and subsequent meetings, participants would linger in the area after the meeting had ended. Participants became more social with others on the team and would talk about various topics. One team had a pattern of interacting for 45 minutes or more following each meeting. In most cases, participants were very social and were anxious to talk about their Second Life experiences.

For the third step, participants were tasked with building their machine. The building process varied by team. In some cases, the third step was completed in multiple sessions. For example, one team met on three different occasions to complete the building process. Other teams split up the work to allow them to complete the building process on their own. Because the designs were modular, individuals would be assigned to build a particular component. They would build the component on their own and then bring that component with them to the next meeting for integration into the overall

machine. In many cases, teams had various objects strewn about their work area. As the teams worked through their designs, the machine would evolve and not all of the objects in the work area would make it into the final design (Figure 5.10).

Figure 5.10. Various Objects used in Design

The fourth and final step was to create a set of instructions to be displayed at the machine (Figure 5.11).

Figure 5.11. Machine Instruction Sign

Step 4 was often delegated to one individual who built the sign and set it up for display at the machine. Because of this, the final meeting was relatively short. Many individuals would wish the others well and most people commented on their experience. Several enjoyed the experience and enjoyed getting to know others in Second Life, over half of the participants commented that it was a positive experience. About one-third of the participants asked if they could come back to visit and meet other participants. One even suggested having an open house event on the island where all the participants could come and visit and interact with the completed machines.

Each group meeting was recorded using video recording software. Still images were also captured throughout the project highlighting specific interactions among group members. These items were used to review how team members interacted with each other and with the technology capabilities. The goal was to obtain specific information regarding avatar behaviors and how individuals used the VW technology capabilities to interact, communicate and complete the project. Review of still images and video revealed that avatars relied heavily on the communication, interaction, and rendering capabilities in Second Life to create objects and show their ideas visually. At the end of each group meeting, an observation log was created that documented specific interactions between individuals, specific uses of the technology, and specific comments made by individuals.

Communication during each group meeting took place using the text chat feature in Second Life. All groups used the text chat log for discussion even though audio chat was available. One group did use audio chat to supplement the text chat. There were a couple reasons for the reliance on the text chat log. In one group, one participant was deaf and required text chat in order to be able to communicate. Another reason is that audio chat creates a lag and can slow down communication. All text chat is stored in a log file that was used as one of the data measurements. Appendix F provides detailed information about the text chat logs that were captured during each meeting, including the length of each meeting and the number of text chat items recorded in the log.

A triangulation approach was used by examining the statistical data captured from the pre and post surveys while simultaneously considering individual actions and team

interactions portrayed in video and still images. Individual and team communication captured in the text chat log were also reviewed in relation to the video and still images. The various data points were used to observe the events that took place within the virtual world and also used to illustrate the conceptual model. Emphasis was based on each specific case (group) in order to take into account the influences of the local context.

Combining these various data sources allowed for a holistic assessment of the findings. The blending of multiple data sources supported the examination of components from a variety of perspectives and enhanced the reliability of the results. The qualitative data supplemented the quantitative data by providing vivid descriptions nested in the real context. The qualitative data was particularly useful for supplementing, explaining, and illuminating the quantitative data captured from the survey.

5.2 Analysis and Discussion of Results

The overarching research question - *How does the use of virtual world technology capabilities affect the development of trust in virtual teams?* served as the basis for analysis and two main propositions were developed in relation to this question and the conceptual model. The following sections present the analysis of the results in relation to the propositions and the change in trustfulness and trustworthiness, the adaptive use of VWTCs (related to changes in trustfulness and trustworthiness), and the overall perception of how the use of VTWCs affected the development of trust in VTs.

5.2.1 Trustfulness and Trustworthiness

One of the primary goals of this research was to evaluate how trustfulness and trustworthiness changed for each individual and for each group. Levels of trustfulness

and trustworthiness were measured quantitatively using a pre and post survey - participants were asked questions relating to their levels of trust at the beginning of the project and then again at the end of the project. The results indicate trustfulness increased in five of the seven groups and trustworthiness increased in six of the seven groups. Although some teams experienced a smaller increase in trustfulness and trustworthiness, overall these constructs increased during the study for most groups.

The following graphs show the statistical means for trustfulness and trustworthiness for each group at the beginning of the study and then again at the end.

Figure 5.12. Comparative Means for Pre and Post Trustfulness

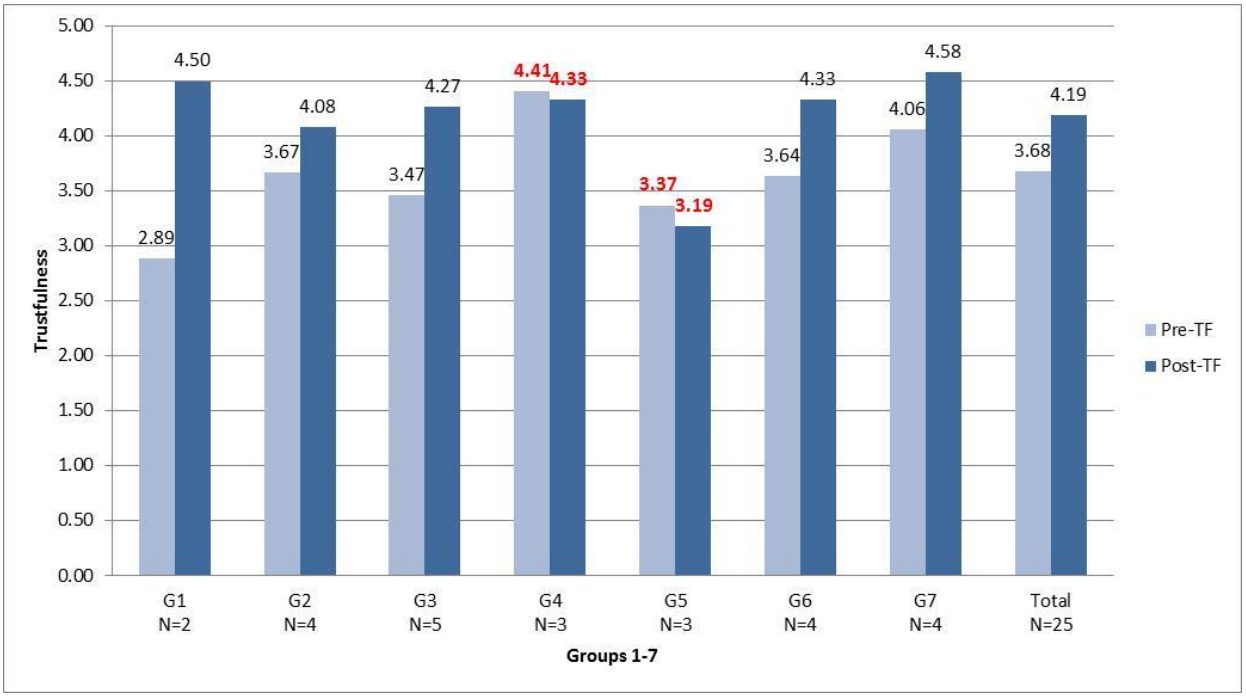
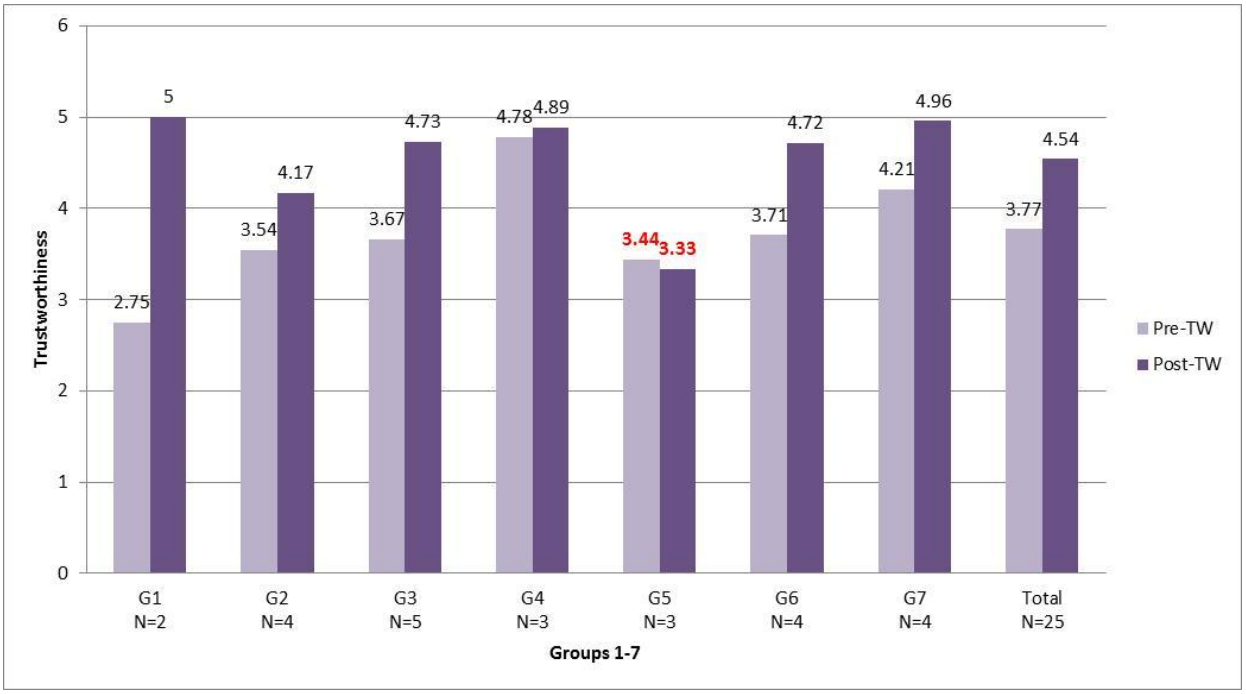


Figure 5.13. Comparative Means for Pre and Post Trustworthiness



Some groups experienced a minimal increase between the pre and post survey. This could be explained by the influence of personality-based trust and institution-based trust, as reflected in the conceptual model. Some individuals started with high levels of trustfulness and trustworthiness prior to joining the team because of high levels of personality based trust and/or institution-based trust. For example, the pre-trustworthiness mean for Group 7 was 4.21 and the post-trustworthiness mean was 4.96 while the pre-trustworthiness mean in Group 1 was 2.75 and the post-trustworthiness mean was 5.

Institution-based trust, a function of an individual's belief in institutional norms and procedures, develops as organizational rules and norms guide an individual's behavior and can foster a trusting environment (Sarker et al., 2003). Individuals gain confidence in another's behavior based on the norms and rules in the institution (organization) (Scott, 1996). During the project, individuals did not belong to a common organization, per se; however, one could argue that Second Life acted as the common institution. Second Life is a community within itself and those who are members of the community share a common institution and Second Life has certain norms and rules that are followed by participants.

The next section provides a detailed discussion of the findings related to the adaptive use of VWTCs, highlighting the social and technical interplays in relation to changes in trustfulness and trustworthiness.

5.2.2 Adaptive Use of VWTCs and Trustfulness/Trustworthiness

The goal of this research was not only to evaluate how trustfulness and trustworthiness changed for each individual and for each group, but to also look at the adaptive use of VWTCs and its relationship to changes in trust levels. Adaptive use of a capability is the nature in which an individual uses or modifies one or more capabilities to perform a task. Adaptive use is based on the fit, inclusiveness, and usage experience of technology.

- *Fit* – the ideal use of a capability or set of capabilities that affect group performance.
- *Inclusiveness* – is the extent to which an individual embraces and utilizes the diverse capabilities provided by the technology.
- *Usage Experience* - the user's experience with using and interacting with technologies.

One-way ANOVA was used to determine if there was a correlation between trustfulness, trustworthiness and the adaptive use of VWTCs. One-way ANOVA tests showed no significance at the .01 or the .05 level between the trustfulness, trustworthiness and fit, inclusiveness, usage experience. The detailed ANOVA statistics are provided in Appendix E.

Correlation analyses were also run to determine if there were any correlations between the constructs. Bivariate correlation showed there was no correlation between post levels of fit or inclusiveness and post levels of trustfulness and trustworthiness at the .01 or .05 level. However, there was a correlation between usage experience and

trustfulness and trustworthiness at the .05 level. Although the quantitative results did not show a correlation between fit or inclusiveness and trustfulness/trustworthiness, the qualitative results offer additional information that indicate the possible existence of a relationship.

Table 5.20. Correlations between Trustfulness, Trustworthiness, Fit, Inclusiveness, and Usage Experience

		Trustfulness Post Mean	Trust-worthiness Post Mean	Fit Post Mean	Inclusive-ness Post Mean	Usage Experience Post Mean
Post Trustfulness Mean	Pearson Correlation	1	.893**	.240	.147	**.429***
	Sig. (2-tailed)		.000	.258	.492	.037
Post Trustworthiness Mean	Pearson Correlation	.893**	1	.126	.265	**.430***
	Sig. (2-tailed)	.000		.557	.212	.036

N=24

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

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

The following table shows the comparative means for fit, inclusiveness, and usage experience based on the post survey.

Table 5.21. Comparative Means for Fit, Inclusiveness, and Usage Experience

		Fit (Post)		Inclusiveness (Post)		Usage Experience (Post)	
Team #	**N**	**Mean**	**Std. Dev.**	**Mean**	**Std. Dev.**	**Mean**	**Std. Dev.**
1	2	2.28	0.202	3.75	0.353	4.37	0.883
2	4	3.57	0.494	4.31	0.554	4.43	0.426
3	5	2.71	0.225	4.25	0.250	4.00	0.612
4	3	2.61	0.733	4.50	0.500	4.41	0.520
5	3	2.76	0.837	3.66	0.288	3.50	0.433
6	4	3.33	0.082	4.00	0.433	4.33	0.577
7	4	3.07	0.633	4.00	0.577	4.12	0.721
Total	25	2.95	0.601	4.10	0.465	4.15	0.593

Scale: 1=Strongly Disagree; 5=Strongly Agree

While the quantitative data reflect that only usage experience was significant, each one of the components of adaptive use offered interesting insights into the change in trustfulness/trustworthiness and will be discussed below.

5.2.2.1 Fit

Fit is the ideal use of a capability or set of capabilities that affect group performance. Participants were asked questions relating to fit on the pre and post surveys. The questions were designed to ask if individuals repurposed capabilities or substituted the capabilities for others to complete the project. The overall mean for fit was 2.95. Based on the survey responses, participants did not feel the need to repurpose the capabilities or change them from their original intent. This suggests that the VWTCs were a good fit for the project.

A review of the qualitative data revealed that participants relied heavily on the VWTCs to complete their projects. For example, participants used text chat as the primary means of communication although email and other methods of communication were available to them. Participants preferred to use the text chat feature even if participants were not online at the time (Second Life stores the message and delivers it

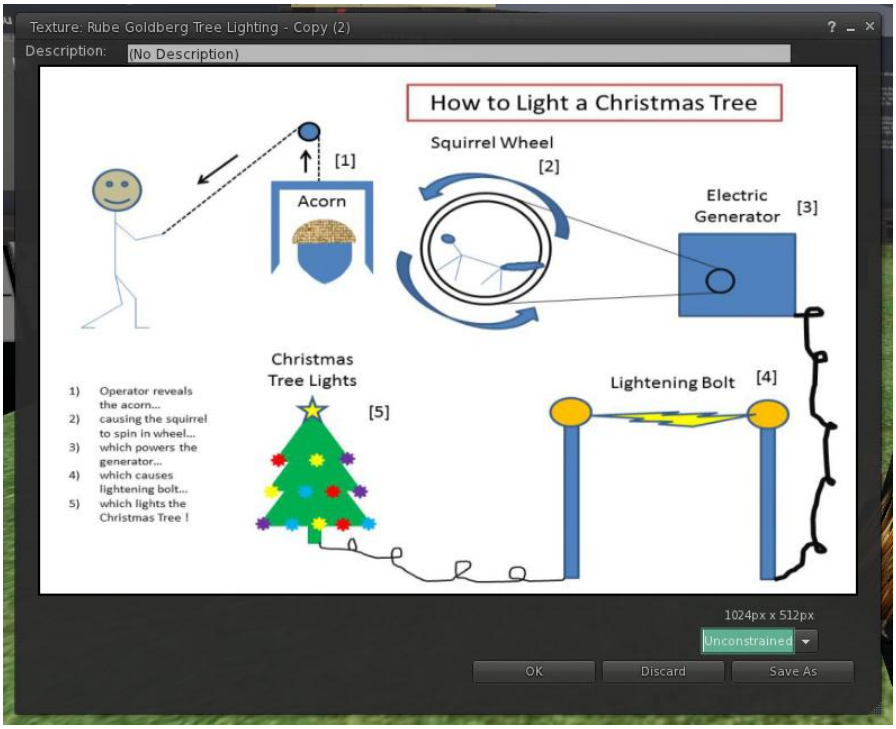
when the person logs into the environment). Similarly, participants relied heavily on the building capabilities available within the virtual world to demonstrate ideas and build components. For example, in Group 3, one participant set up several sample objects with different textures and asked everyone to vote on them (Figure 5.14). Everyone in the group was able to visualize the objects before choosing one for the final machine.

Figure 5.14. Voting on Textures

To further illustrate the wide use of building capabilities, each team submitted a different form of a design document using the technology capabilities within Second Life to present the document. For example, one team delivered a formal design document in PDF form while another delivered a diagram via an image displayed on an in-world object. Another team used the technology capabilities to build a white board and posted objects onto the whiteboard to represent their machine design and yet another built a mini-model of their design. The following images represent the different ways teams documented their design.

Group 2 imported an image into Second Life as a texture and the texture was shared with everyone in the group.

Figure 5.15. Group 2 Design Document

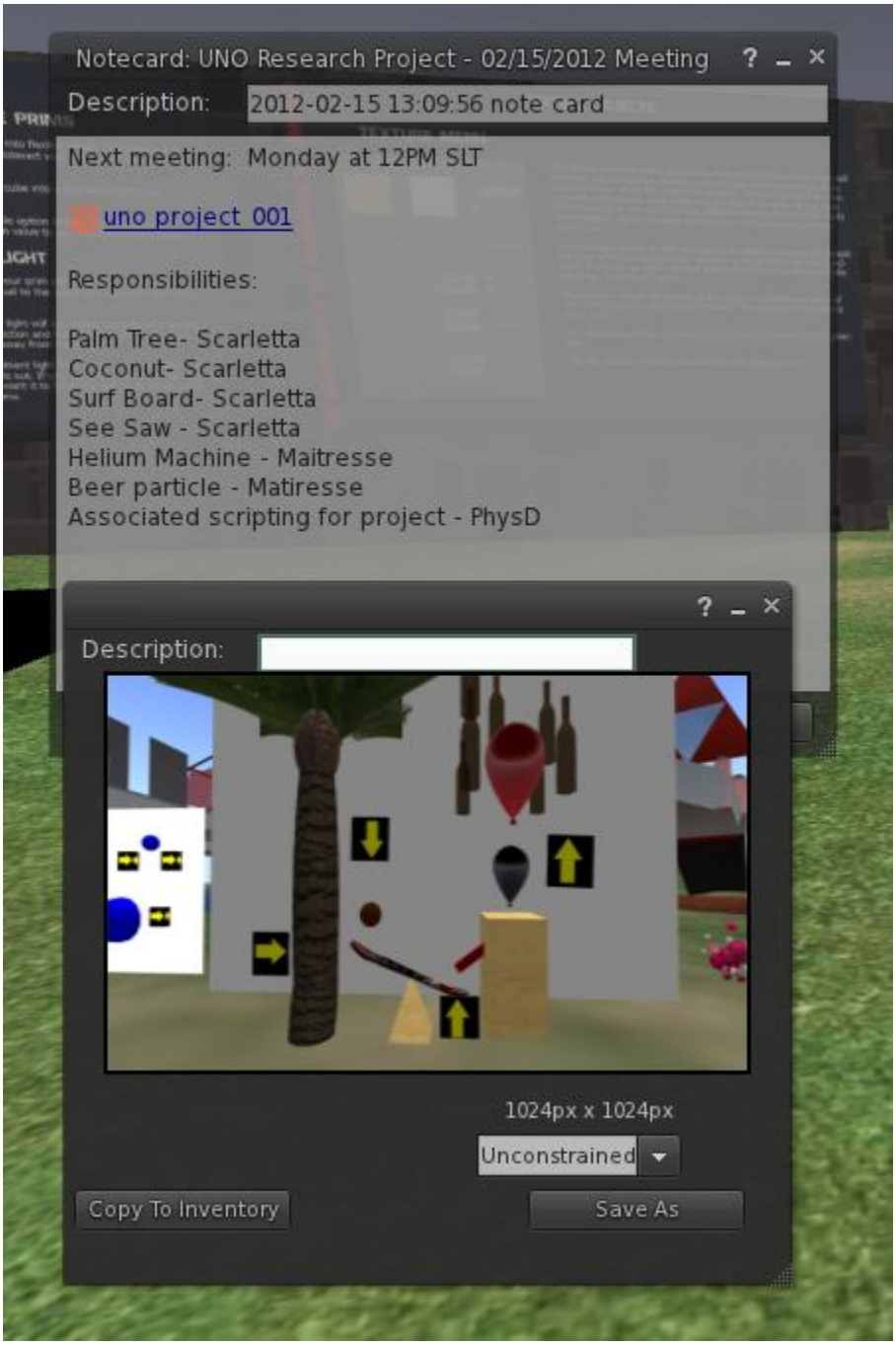


Group 3 documented their design using the text chat log.

> *[2011/12/08 18:35] Participant1: "Avi presses a button to shoot a cannon."*
> *"Cannon shoots ball"*
> *"into Plinko"*
> *"Ball goes through plinko"*
> *"Ball goes into spiral"*
> *"ball activates boot..."*
> *"boot kicks base of 'flag pole'"*
> *"Sends toast up (raises a toast)"*

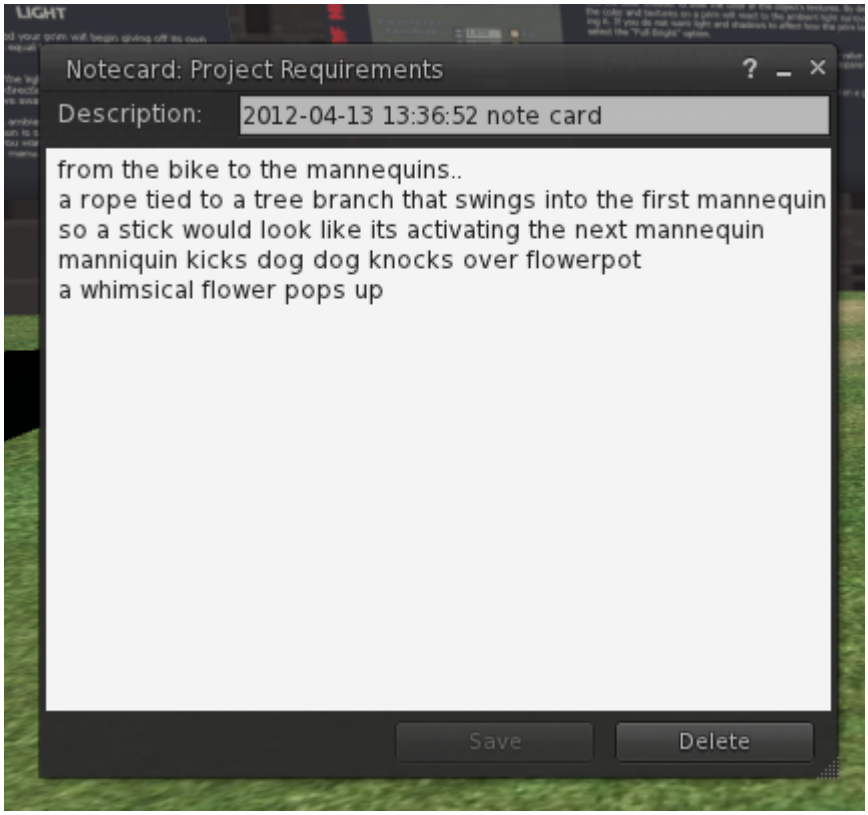
Group 5 created a white board to draw their design. When finished they took a picture of the white board. They then created a notecard with a link to the picture and included who was responsible for each component on the notecard.

Figure 5.16. Group 5 Design Document



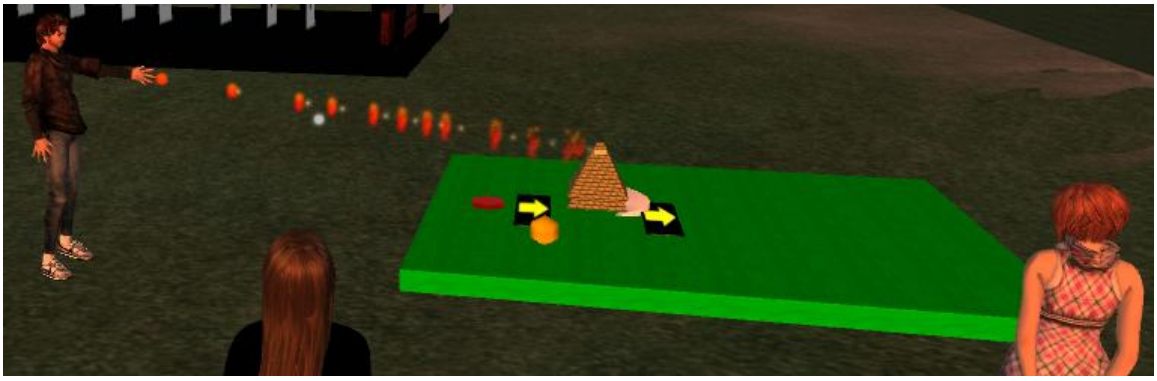
Group 7 described their design on a notecard and then shared the notecard with everyone in the group.

Figure 5.17. Group 7 Design



Group 8 created a mini-model of their machine using the objects and textures available in Second Life.

Figure 5.18. Group 8 Design



A final observation with regard to fit relates to the complexity of the machines that were created as a result of the project. Participants were given very simple project requirements (refer to Table 4.8 for detailed project requirements); however, the machines they created were very complex. The requirements called for at least three different components one of which must be a circular object and one a rectangle. In the final designs, machines contained anywhere between three and six components. In one group, a hamster wheel represented the circular object and in another group it was a coconut. Many of the groups used dominoes to represent the rectangle object. Appendix H includes a picture of each of the finished machines. Examples of two of the finished machines are included here to show their complexity.

Figure 5.19. Group 2 Final Rube Goldberg Machine

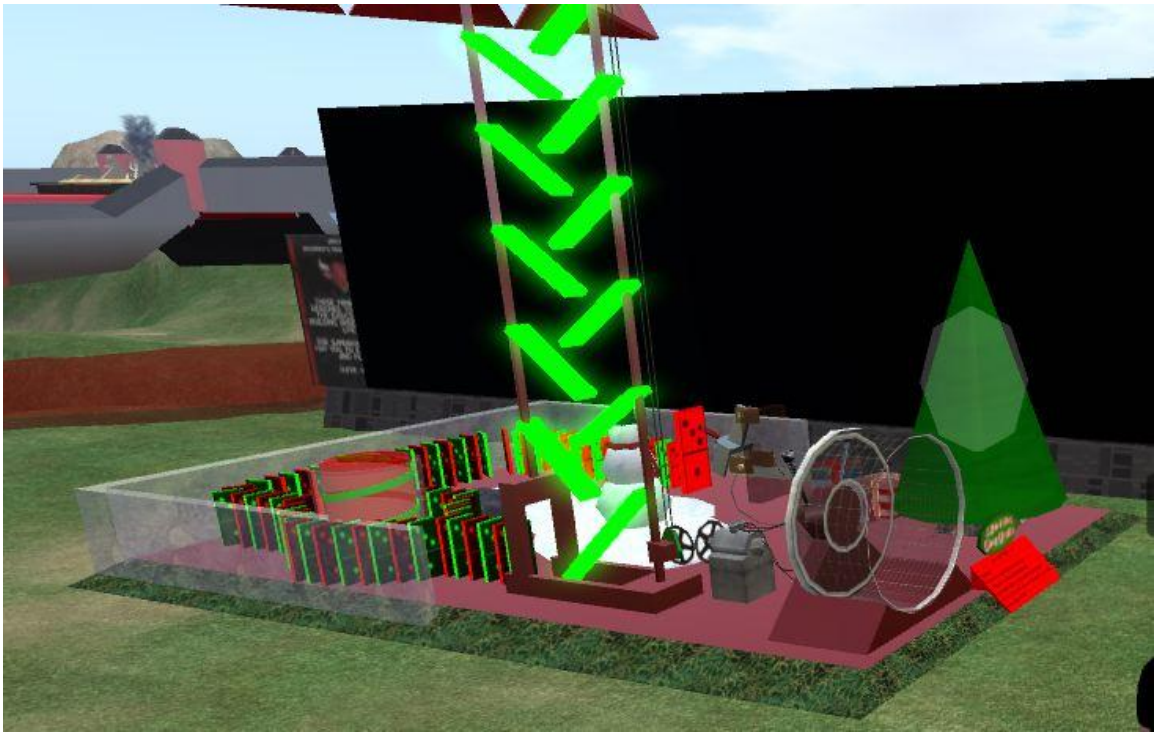


Figure 5.20. Group 7 Final Rube Goldberg Machine

Participants in the study were very comfortable with the technology and were knowledgeable about the capabilities; this could explain why the machines were complex. Another potential explanation could be related to the capabilities themselves, as the VW offered unique capabilities that allowed the teams to build complex machines. Each group fit the capabilities in a way that affected team performance.

The following visualization was created as another way to look at fit in relation to trustfulness and trustworthiness. These concepts were measured on a 5 point scale and each group was plotted into one of four quadrants based on their post mean score for trustfulness, trustworthiness, and fit. Generally, the overall trustfulness and trustworthiness score was relatively high. Therefore, in order to delineate groups into quadrants the mean score was used. These pictures were used to help identify outliers and patterns among groups.

Figure 5.21. Trustfulness and Fit Quadrants

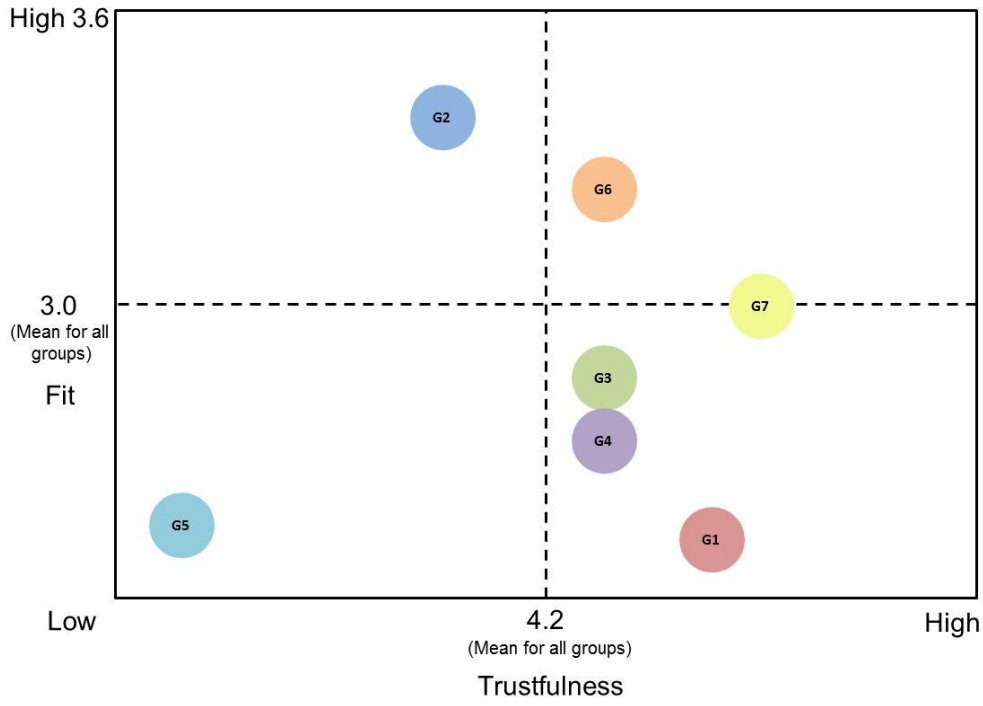
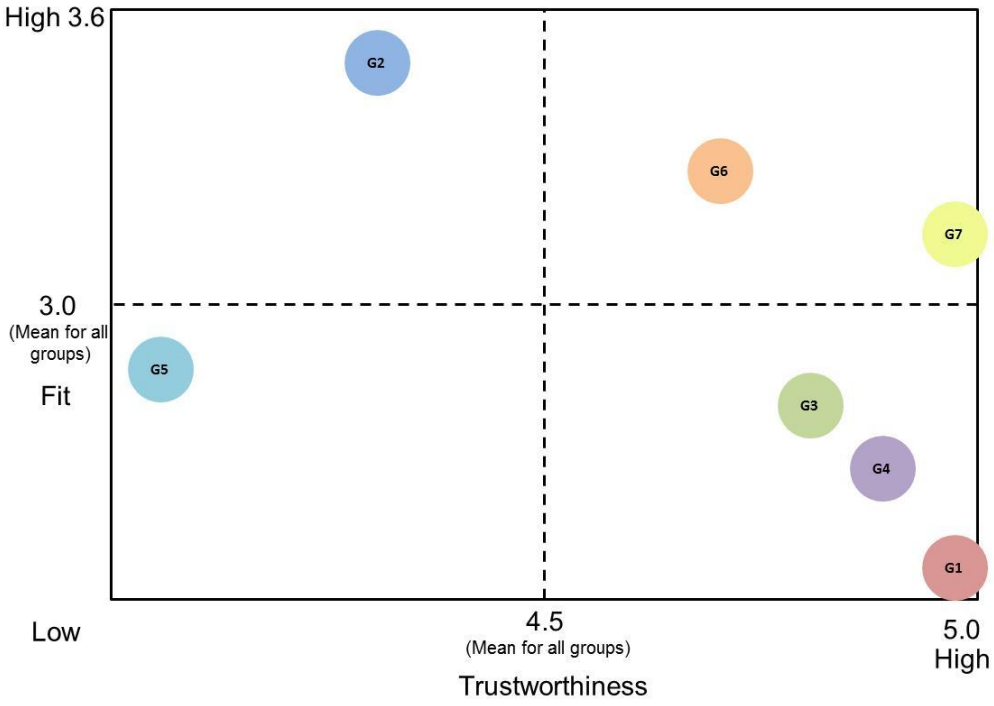


Figure 5.22. Trustworthiness and Fit Quadrants



A few general observations can be made about the diagrams. First, there is a group in each of the four quadrants. Second, each group viewed fit in different ways, and third, each group remained in the same quadrant for trustfulness and trustworthiness. A closer look at the diagrams shows some strong variations between the groups. For example, Group 5 is in the low fit, low trustfulness/trustworthiness quadrant, while Group 6 is on the opposite end with high fit and high trustfulness/trustworthiness. And Group 2 is in the high fit, low trustfulness/trustworthiness quadrant, while Group 1 is on the opposite end with low fit and high trustfulness/trustworthiness quadrant.

Some interesting questions arise when looking at the differences between groups. For example, what was unique about Group 5 and why was it the only group with low fit and low trustfulness/trustworthiness? What was unique about Group 2 and why was it the only group with high fit and low trustfulness/trustworthiness? Both Group 1 and Group 6 had high trustfulness/trustworthiness, but each differed in relation to fit – one had low fit and one had high fit. What was different about fit in each group?

To answer these questions, the various data sources were reviewed carefully to determine if there were differences in the way the groups adapted the VWTCs. It is important to note that Group 5 did not meet the project requirements. After reviewing the videos for Group 5, it seemed that this group lacked a collaborative work environment. During the group meetings for this group, one person would build and place objects while the others stood and watched and provided commentary. The others did not participate in the building process. There was little discussion before, after, or during the meetings. An analysis of the text chat log also confirms that there was little

communication in this group as compared to other groups. For example, in Group 5, the meeting for Step 3 was 2 hours and 12 minutes with 365 lines in the text chat log. Group 6, a group with high fit and high trust had much more communication and collaboration. Their meeting for Step 3 was 1 hour and 30 minutes with 437 lines in the text chat log. The following diagrams show these differences in communication between Group 5 (low fit/low trustfulness/trustworthiness) and Group 6 (high fit/high trustfulness/trustworthiness).

Figure 5.23. Communication and VWTCs used for Group 5

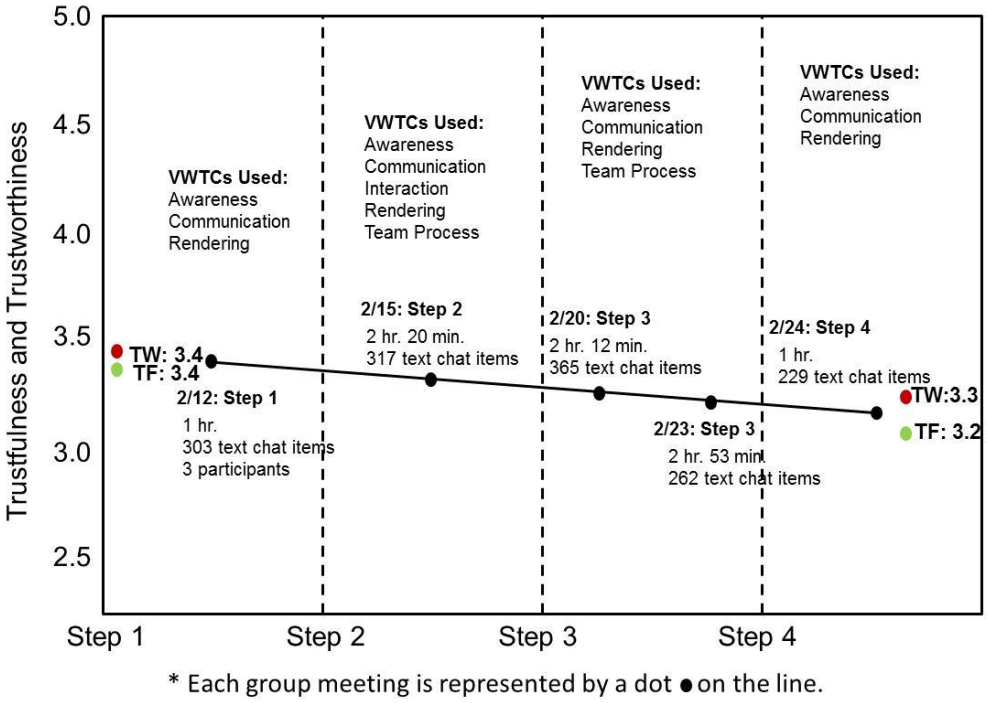
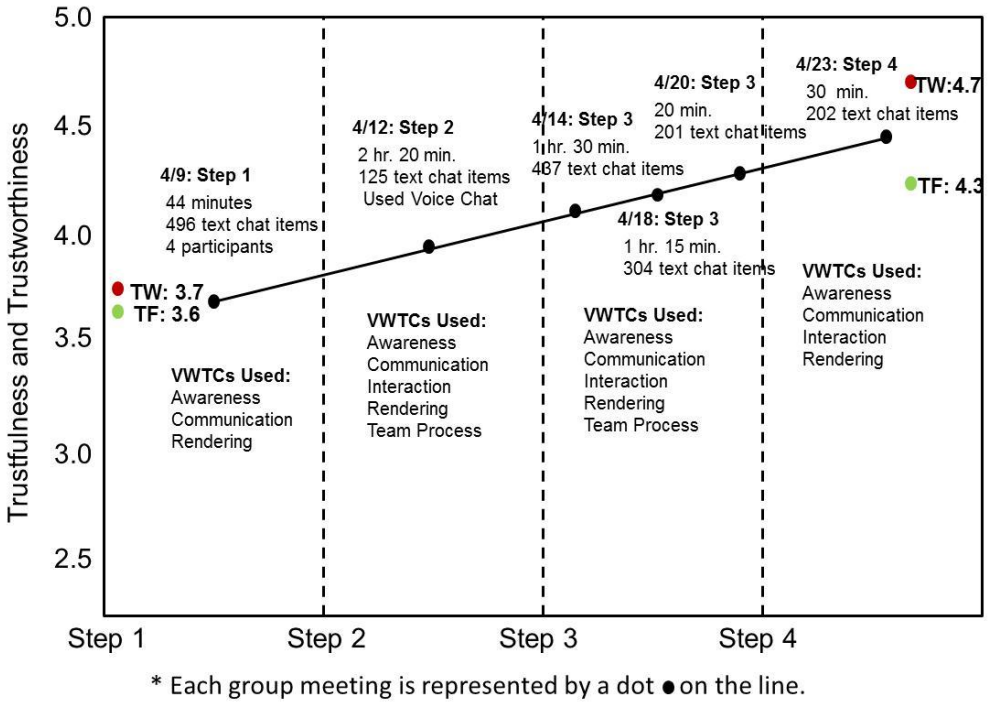


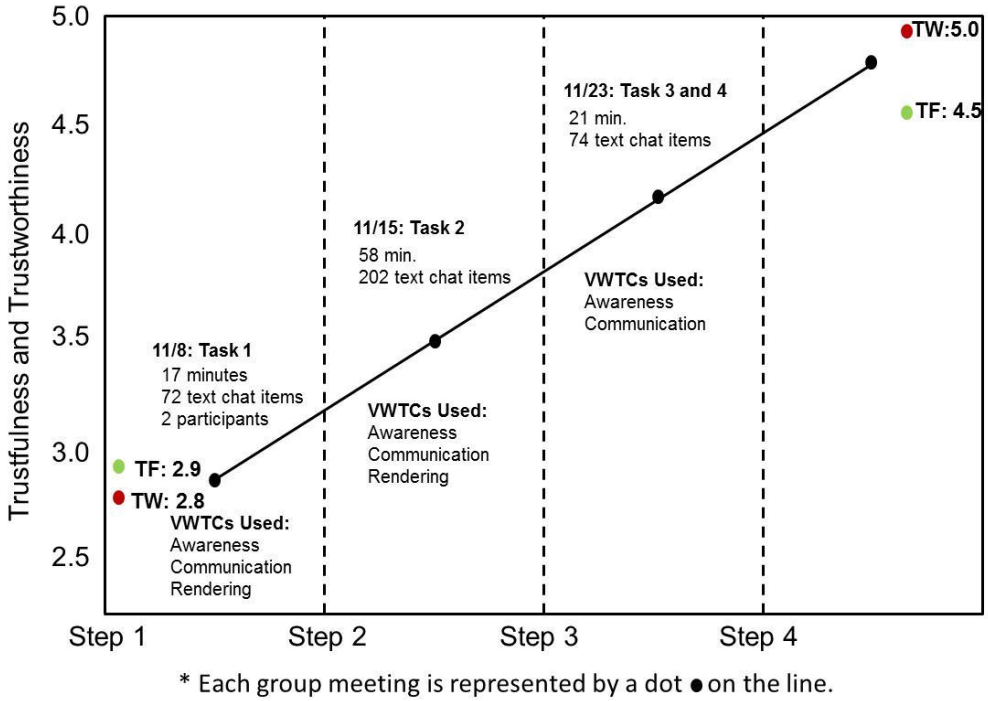
Figure 5.24. Communication and VWTCS used for Group 6



* Each group meeting is represented by a dot ● on the line.

Group 1 had low fit and very high trustfulness/trustworthiness falling into the Low/High quadrant. This group was unique in that there were only two participants and they completed the building of the machine on their own. They divided up the work and each would complete the parts on their own and then come to the meeting with their completed work. Their meetings were very brief and there was not much interaction during meetings. The following diagram shows the communication for Group 1. It also shows that Group 1 used fewer capabilities as compared to other groups. Interestingly, the ending scores for trustfulness and trustworthiness for Group 1 were the highest of all the groups. This could be because there were only two participants in the group and each felt comfortable with the ability of the other to deliver their part of the project

Figure 5.25. Communication and VWTCS used for Group 1



In summary, *participants appeared to fit the VWTCs in different ways to affect group performance*. Some groups had low fit but high trustfulness/trustworthiness while others had high fit and high trustfulness/trustworthiness. While each group had different results, the technology provided the needed capabilities to complete the steps in the project and each group delivered machines that were more complex than the original requirements. The findings about fit support task-technology fit (TTF) theory which suggests that an appropriate task/technology fit results in higher performing teams (Goodhue and Thompson, 1995). In the context of this research, an appropriate task/technology fit resulted in higher performing teams, or teams that were able to

complete the project. This was evidenced by the use of VW technology capabilities in each step of the project. The findings highlight the importance of task/technology fit in relation to team outcomes. However, future research is needed to explore the relationship between fit and trustfulness and trustworthiness.

5.2.2.2 Inclusiveness

Inclusiveness is the extent to which an individual embraces and utilizes the diverse capabilities provided by the technology. Although the quantitative results did not show a correlation between inclusiveness and trustfulness/trustworthiness, the qualitative results indicate that there was high inclusiveness. Participants relied heavily on all the technology capabilities available within the virtual world to complete their projects, not just one or two of them. The findings suggest that the inclusiveness of the technology in relation to the task work together to create a desired outcome. In the context of this research, the teams that had high inclusiveness also met the project requirements.

As the teams progressed through the steps in the project, participants used more capabilities. Step 1 was simply a "Meet and Greet". Participants did not use many of the capabilities other than communication and the meeting for Step 1 was relatively brief. As each team moved to Step 2 (Design) and Step 3 (Build), they used many of the capabilities together and the meetings became longer in length. Participants also communicated more via the text chat log. Step 4, create a sign for the machine, was a relatively easy step and participants used fewer capabilities. The final meeting was again relatively brief in comparison to the other meetings.

The following matrices show the variations in groups for inclusiveness, trustfulness and trustworthiness. These concepts were measured on a 5 point scale and each group was plotted into one of four quadrants based on their post mean score for these constructs.

Figure 5.26. Trustfulness and Inclusiveness Quadrants

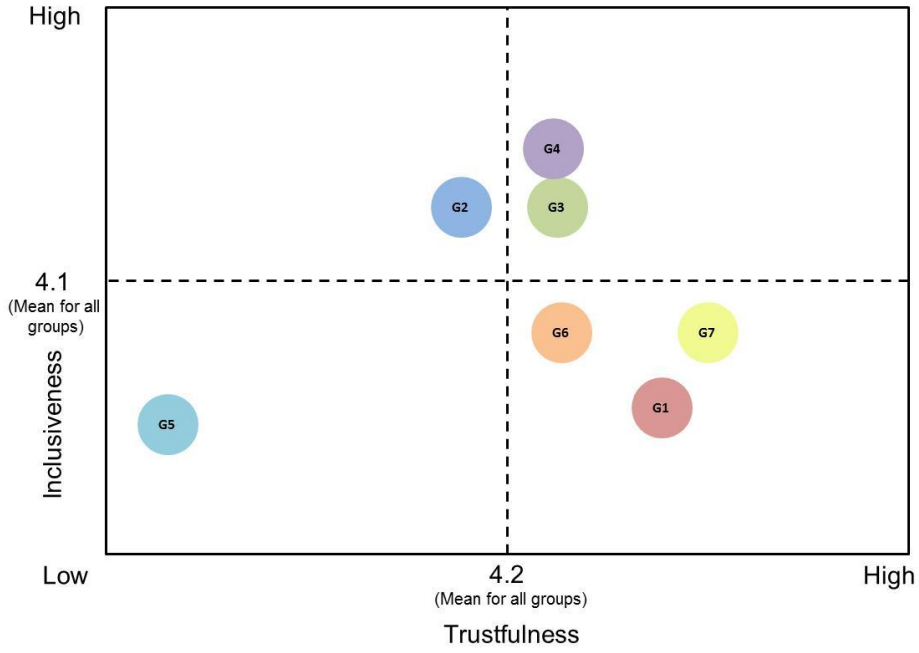
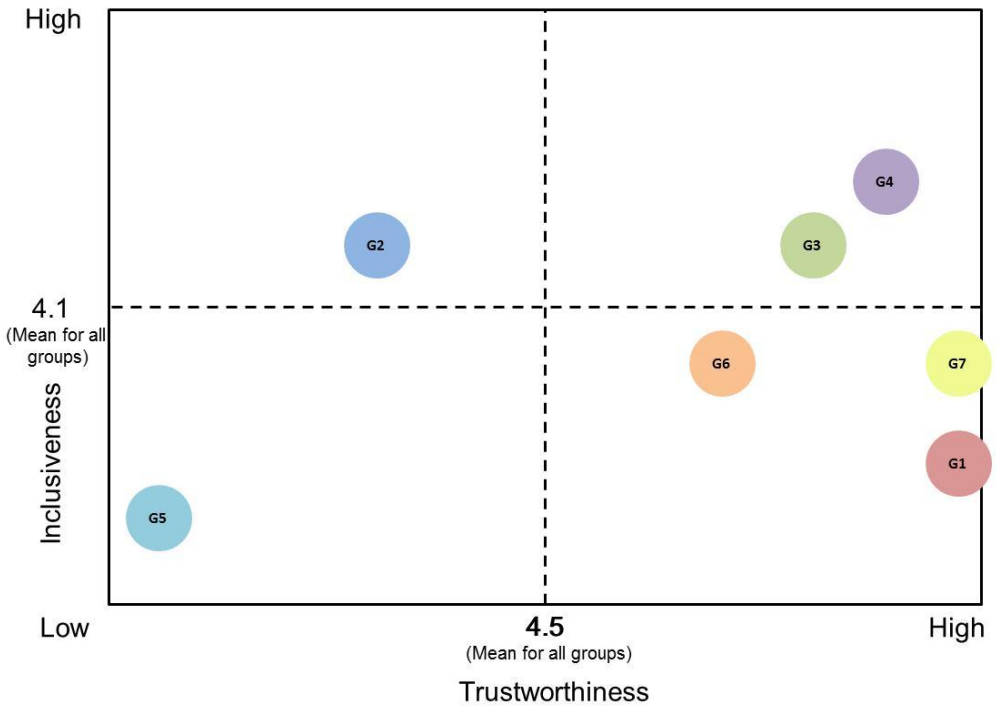


Figure 5.27. Trustworthiness and Inclusiveness Quadrants



A closer look at the diagrams shows that inclusiveness was different for each group and each group remained in the same quadrant for trustfulness and trustworthiness. This is not surprising since the correlation between trustfulness and trustworthiness was high. The diagram shows that Group 4 had high inclusiveness and high trustfulness and trustworthiness in relation to the other groups while Group 5 had low trustfulness and trustworthiness and low inclusiveness. Group 5 continued to be an outlier and the only group in the low inclusiveness low trustfulness/trustworthiness quadrant.

The qualitative data were again carefully reviewed to determine if there were differences in the way the groups adapted the technology. This review highlighted some differences in the inclusiveness of the technology in each group. As discussed in the previous section, Group 5 did not meet the project requirements and used fewer of the VWTCs for each step in the project (a list of the specific technology capabilities available

in Second Life is provided in Table 4.12). Group 5 also had fewer lines in the text chat log. Group 3 and Group 4 had high inclusiveness and high trustfulness/trustworthiness. The following diagrams reflect the changes in the use of VWTCs for each step for Group 3 and Group 4. It also shows the total meeting time for each step and the total number of items in the text chat log. (Similar diagrams for each group can be found in Appendix G.)

Figure 5.28. Communication and VWTCS used for Group 3

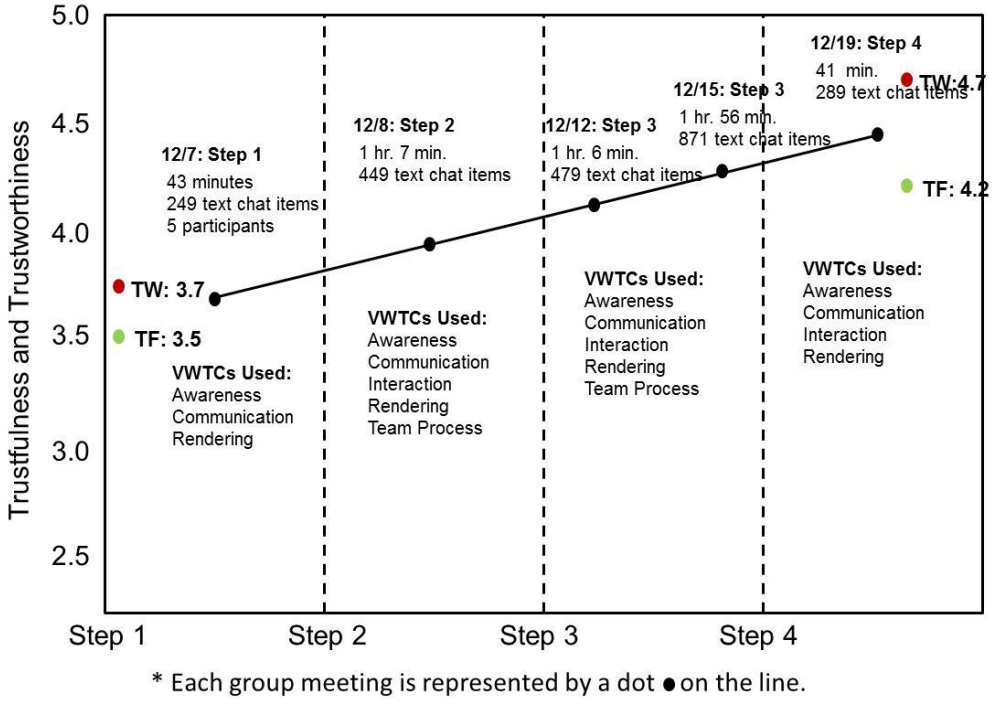
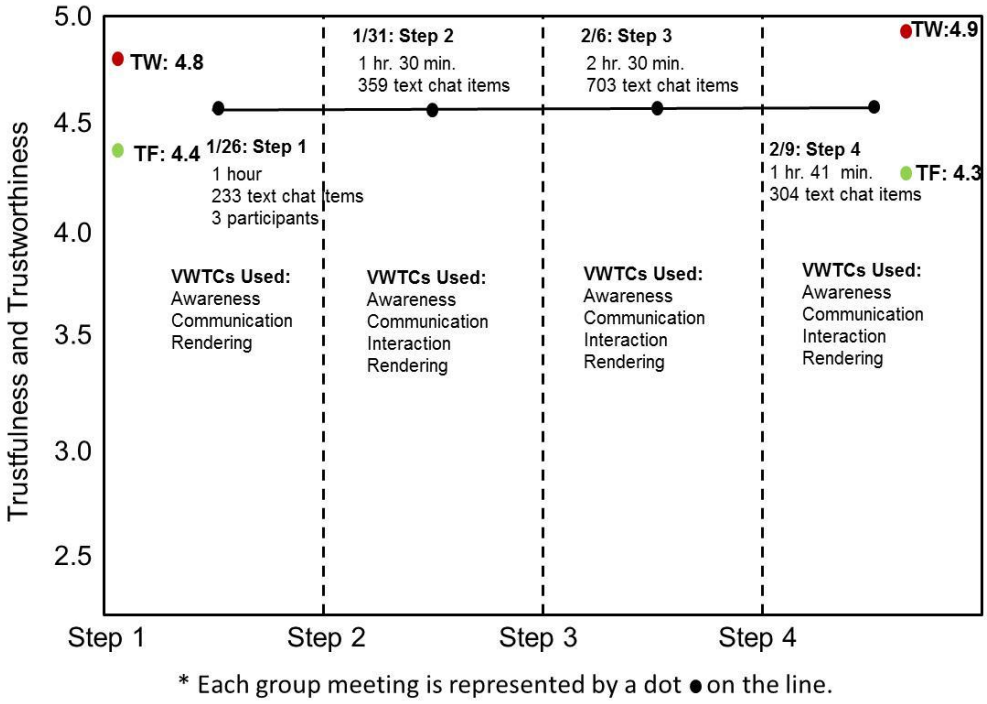


Figure 5.29. Communication and VWTCS used for Group 4



In both groups, during Step 1 and Step 4 of the project, participants used fewer capabilities and spent less time to complete that step. For Steps 2 and 3, participants relied on all of the capabilities and required more time to complete task. They did not look to outside capabilities or tools and relied only on the capabilities available within Second Life. The qualitative data further suggests that the VWTCs available within Second Life were sufficient for the task and helped facilitate trust building. All of the participants in the study were very familiar with Second Life and its capabilities. This could explain why participants were aware of the capabilities and were also comfortable

using the capabilities to complete each step. Participants did not have to learn new technology.

Interestingly, the groups that experienced a decrease in trustfulness/trustworthiness (Group 4 and Group 5) had difficulty with the scripting portion of their project. Scripting is considered a rendering capability (see Table 4.12). Group 5 was also one of the groups that did not meet the all of the project requirements. Each group had to incorporate some degree of scripting in order to make the objects in their machines interact with each other to simulate a chain reaction. Group 5 did not meet all the requirements of the project because the objects in their machine did not interact with each other and the machine itself was not able to be started or stopped by another observer (Requirement 4). Some of the other groups had challenges with scripting; however, they used teamwork to address the problem by calling upon other Second Life residents or browsing through Second Life resources together to find a solution. Participants in Group 4 and Group 5 did not collaborate to find a solution to the scripting challenge. Instead, they either left the machine in an unfinished state, or let one person try to add the scripting required.

In summary, the capabilities unique to VWs were sufficient for each of the steps in the project. Some steps were more complex than others and participants used multiple capabilities to complete those steps. The data suggests that people were comfortable with the technology (they did not have to learn it) and this allowed them to focus on the project and also focus on building trust. The findings offer support for the general proposition.

Proposition 1*: The adaptive use of VW technology capabilities affects individual trustfulness and trustworthiness.*

Future research is needed to further explore the relationship between inclusiveness and trustfulness and trustworthiness. The following are possible propositions that might be used to further explore this relationship.

Proposition 1a: *The greater the inclusiveness of VWTCs, the higher the level of trustfulness.*

Proposition 1b: *The greater the inclusiveness of VWTCs, the higher the level of trustworthiness.*

Proposition 1c: *The higher the level of trustfulness, the greater the inclusiveness of VWTCs.*

Proposition 1d: *The higher the level of trustworthiness, the greater the inclusiveness of VWTCs.*

5.2.2.3 Usage Experience

Usage Experience is the user's perception about their experience using and interacting with the technology. Usage experience was the only construct in adaptive use that had a correlation between post levels of trustfulness and trustworthiness at the .05 level. Participants were asked questions relating to usage experience on the post survey. The questions asked about the individual's perception about the use of capabilities in relation to performance, productivity, effectiveness, and project completion. The overall mean for usage experience was 4.2.

Both the qualitative and the quantitative findings suggest that participants who used a greater variety of VW technology capabilities to complete the project also had higher levels of trustfulness/trustworthiness. A review of the qualitative data revealed that participants relied heavily on the VWTCs to complete their projects. Each team adapted the capabilities to complete the steps, thus explaining the correlation. The previous sections on fit and inclusiveness described how individuals and groups utilized the capabilities to complete each step and will not be repeated here.

The following matrices show the variations in groups for usage experience, trustfulness and trustworthiness. These concepts were measured on a 5 point scale and each group was plotted into one of four quadrants based on their post mean score for these constructs.

Figure 5.29. Trustfulness and Usage Experience Quadrants

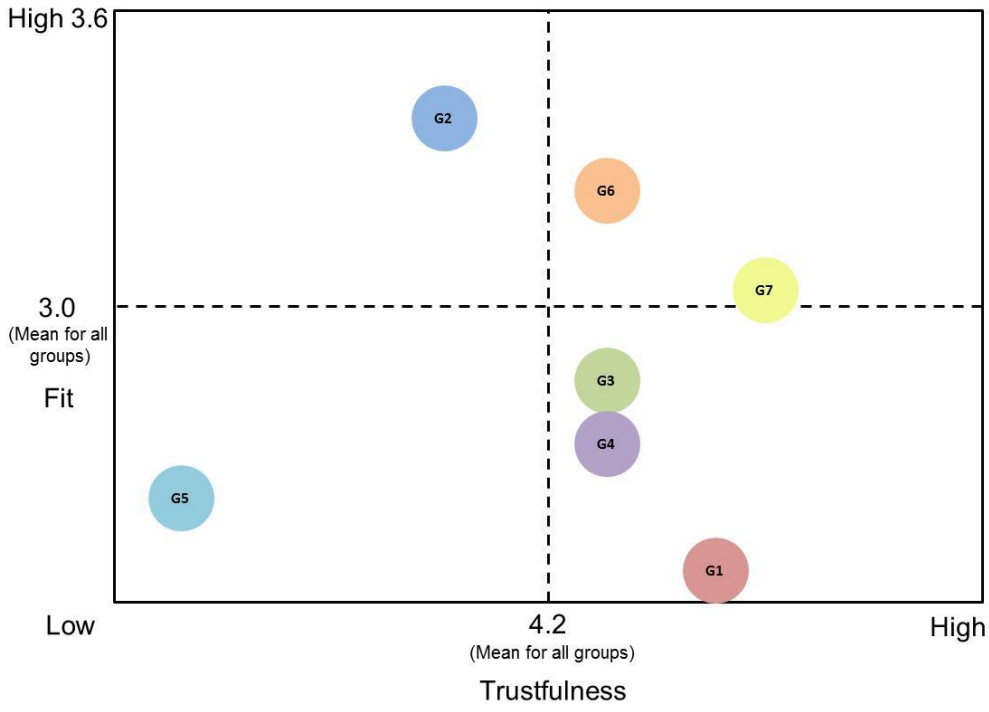
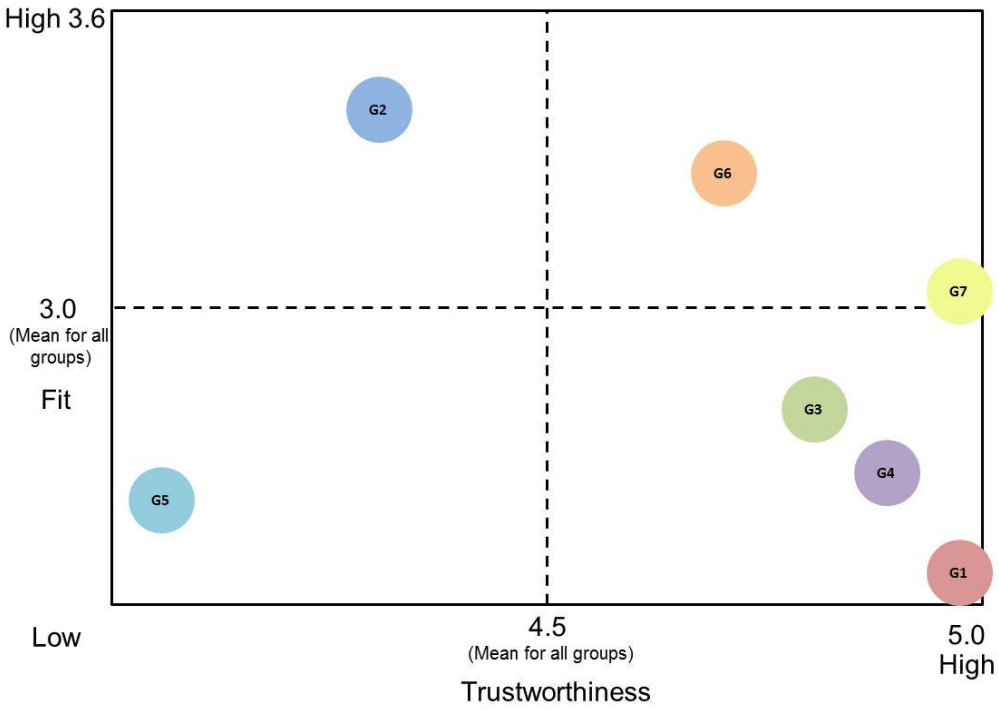


Figure 5.30. Trustworthiness and Usage Experience Quadrants



Group 5 again fell in the low usage experience and low trustfulness/trustworthiness quadrant. *This group did not meet all the requirements, did not use as many of the technology capabilities, had fewer communication items in the text chat log, and had lower usage experience*. Group 7, on the other hand, fell in the high usage experience and high trustfulness/trustworthiness quadrant. While this Group 7 struggled with some of the scripting elements and as a result did not meet all of the requirements, the group had high levels of trustfulness/trustworthiness. Additionally, they had a high usage experience. This can be attributed to their use of the technology and a collaborative group where everyone worked together to build the machine as evidenced by the number of communication items in the text chat log and a review of the video.

In summary, the participants that felt the VWTCs were helpful in completing the project also showed an increase in trustfulness/trustworthiness. These findings support the main proposition:

> ***Proposition 1****: The adaptive use of VW technology capabilities affects individual trustfulness and trustworthiness.*

A collective review of all the matrices shows that each group was consistent in each of the three areas – fit, inclusiveness, and usage experience and their placement into the quadrants. Based on this information, we can begin to develop "ideal profiles" for each of the quadrants in the grid. In the ***low*** (fit, inclusiveness, usage experience), ***low*** (trustfulness/trustworthiness) quadrant there was less communication, little collaboration, and not everyone participated in the building process. Additionally, fewer capabilities were used during the project. The following examples of communication were taken from the text chat log highlighting a less collaborative environment.

> *"Well I'm thinking that 2 of us are kinda just standing here."*
>
> *"Looks like you need time to adjust scripts.. so maybe it makes sense to let him do that.. just like we did building on our own..and come back and clean it up a bit."*
>
> *"Oh ok.. guess its just me.. I'm not really sure what he's doing or having trouble with.. are you guys in voice?"*
>
> *"I'm just standing here being useless, lol"*
>
> *"I wasn't trying to be negative.. it was more of a matter of fact observation :) I am just the type of person that likes to make good use of time. If I can help in some way.. let me know what you need.. but me standing here watching you touch an object seems like a waste to me."*

In the ***high*** (fit, inclusiveness, usage experience), ***low*** (trustfulness/trustworthiness) quadrant there was more communication and more collaboration. However, the participants had lower trust. While there was a collaborative work environment, participants relied heavily on one person to do much of the project work. For example, in Group 2, one person came to the meeting and provided ideas, but seemed more interested in building objects not related to the project. This participant created a music box to play music while others worked. In the ***high*** (fit, inclusiveness, usage experience), ***high*** (trustfulness/trustworthiness) quadrant, there was high communication, high collaboration, and everyone participated on the project. The following examples of communication were taken from the text chat log highlighting a helpful environment.

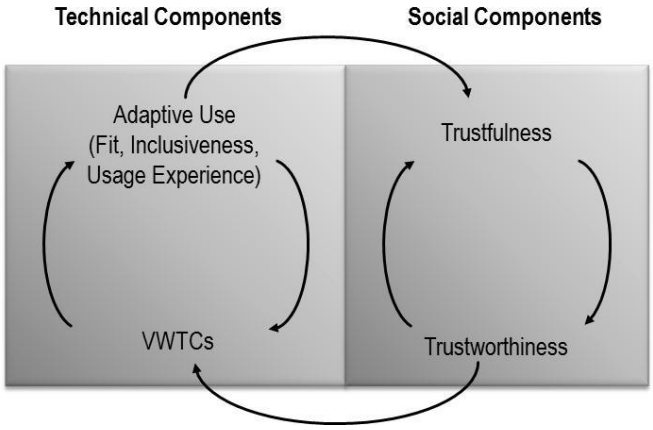
> *"Can you work on the bike? and do you need any parts to that, that i could help with?"*
>
> *"I own a texture and sculpt business so can help with that if needed"*
>
> *"If you need anything i can help with please im"*

In the ***low*** (fit, inclusiveness, usage experience), ***high*** (trustfulness/trustworthiness) quadrant participants had high communication and collaboration, however, used fewer capabilities to complete their projects (e.g. Group 1 did much of the work on their own and came to the meeting with their completed objects).

The research was viewed through a socio-technical lens which highlights the context of work practices and takes as its underlying premise the interdependencies between the social aspects of work and technology (Bostrom & Heinen, 1977; Adman & Warren, 2000; Lamb & Kling, 2003). Prior research on VWs found that the interplay

between social and technical components that affects team processes and project outcomes (Owens et al., 2010). This research also supports the socio-technical perspective; it is the interaction between the social and technical components that affects team process and the development of trustfulness and trustworthiness. Figure 5.33 represents key portions of the model from a socio-technical perspective, highlighting the interaction between the social and technical components.

Figure 5.31. Adaptive Use of VWTCs affecting Trustfulness and Trustworthiness



Trustfulness and trustworthiness represent the social components while the technical components are the adaptive use of VWTCs and the task. The quantitative findings suggest that these social and technical components work together to create a desired outcome.

Overall, the results indicate that at the start of the project, individuals had lower levels of trustfulness and trustworthiness. In most cases, trustfulness and trustworthiness did increase during the two week projects leading to higher levels of trustfulness and trustworthiness at the end of the project. The teams relied heavily on the VW technology capabilities to complete their project and for communication. There are also several

opportunities for future research in order to explore how specific VWTCs affect the development of trustfulness/trustworthiness in VTs.

5.2.3 The Use of Specific VWTCS and Individual Trustfulness/Trustworthiness

A second main proposition was developed in order to address the specific research question - *How does the use of virtual world technology capabilities affect the development of trust in virtual teams?*

> ***Proposition 2:*** *Individual trustfulness and trustworthiness is positively influenced by the use of specific VWTCs such as awareness, communication, interaction, rendering, and team process.*

In observing each of the project teams, observations were made about the specific use of VWTCs. For example, comments were made about rendering and interaction capabilities. Rendering capabilities support the process of creating life-like images such as avatars and objects in the virtual world environment. Individuals create avatars to represent themselves in the virtual world and avatar appearance is important for many individuals. Avatar appearance seemed to be important in the project. Interaction capabilities support the process of people and avatars working together with others and engaging in the virtual world environment. Interaction capabilities allow individuals to control their avatar by making them move and also encompass immediacy of artifacts. These capabilities are important in displaying nonverbal communication in the virtual world. The following sections provide a discussion of how the use of specific VW technology capabilities – avatar appearance, avatar non-verbal communication, and immediacy of artifacts – affected trustfulness/trustworthiness.

5.2.3.1 Avatar Appearance

In face-to-face communication, individual appearance plays a role in trust (Lea and Spears, 1995). In most VTs, the effect of individual appearance on trustfulness/trustworthiness is lost due to geographic distances and the difficulty of meeting face-to-face. VWs offer a unique opportunity related to appearance in that individuals can customize their avatar's appearance within Second Life. Many participants in the study put considerable effort into their avatar's appearance. Participants wanted their avatars to look a certain way, often paying money for their clothes. Many people purchase clothing, gestures, and animations for their avatars. One of the participants in the study owned their own clothing shop within Second Life in which they designed and sold clothes. Another participant had more than 500 inventory objects relating to avatar appearance. Avatar appearance was also a topic of discussion in casual group conversation. The following excerpts from the text chat logs highlight the importance of avatar appearance in group interaction.

Table 5.22. Excerpts from the Text Chat Log Regarding Appearance

Participant Comments (Excerpts)
"well I don't always look like this see haha" *"You said you dressed professionally for the meetings"* *"Yes. For example,): I don't like my "default" avatar look, before I came here I was dressed this way [changing appearance] and you can really do it up here in Second Life. Of course many days I'm an elf or faerie or other things as well. It just depends on my mood haha."*
For this project, I will be using my "professional" avatar, Professor X.

Most of the participants would dress their avatar professionally for the occasion. However, in Group 3, one participant was dressed provocatively as a night dancer. However, this did not seem to have an overall effect on trustfulness or trustworthiness.

This could be because there were four other people in the group who were dressed professionally. In many cases, avatars wore different outfits for each meeting, suggesting that they changed their outfits frequently. The following figure includes images of some of the avatars who participated in the study.

Figure 5.32. Images Representing Avatar Appearance

Individuals also have the option of representing themselves as animals. In two of the groups, individuals represented themselves as animals. In Group 4, one individual was represented by a centaur and in Group 5 one individual was represented by a small cat (Figure 5.35).

Figure 5.33. Images Representing Non-human Avatar Appearance

Interestingly, Group 4 showed lower levels of post trustfulness and Group 5 had lower levels of post trustfulness and trustworthiness.

The data might suggest that avatar appearance is related to one's embodied social presence (ESP). ESP is premised on the notion that the body is the center of communication and an embodied representation, such as an avatar, affects the perceptions of individuals by drawing them into a higher level of cognitive engagement in their shared activities and communication acts (Mennecke, 2011). In VWs, all verbal and nonverbal communication acts and cues are filtered through this embodied representation of the individual. When a user of a virtual environment is presented with a body representing himself or herself in the VW, that representation will have an influence on perceptions of self, identity, and the user's actions associated with that representation (Biocca, 1997). Thus, embodied presence creates an opportunity for the individual to

develop and extend his or her identity by dressing their avatar in a way that represents them. An embodied presence creates an opportunity for the individual to develop and extend his or her identity in the virtual environment and this can help people create an identity for themselves, identify with others, and promote the development of trust (Mennecke, 2011). The avatar is no longer another digital representation walking around; rather a deliberate representation of what the person operating the avatar wants others to see.

The extent of the avatar's customization seemed to represent the avatar engagement in the VW and the person's comfort level with the VW technology. For example, when creating a new avatar one is given the option to choose from several default appearances. It is from these out of the box avatars that people begin to make changes to their appearance. As people become more comfortable with the technology and the VW, they begin to make changes to their avatar's appearance. In many conversations within groups, avatars were called out as "newbies" just based on their avatar appearance due to their lack of customizations.

It is not clear what effect avatar appearance has on levels of trustfulness/trustworthiness; however, the results indicate there may be a relationship between avatar appearance and trustfulness/trustworthiness. More research is needed in order to explore this relationship further.

5.2.3.2 Avatar Non-Verbal Communication

VW technology capabilities (VWTCs) allow users the ability to mimic physical characteristics and actions in the virtual environment. The important visual cues,

physical appearance, posture, gestures, body movements, and nonverbal cues, used in the development of trust were available using the capabilities offered in a virtual world. Since nonverbal cues are central to the communication of trust (Ekman & Friesen, 1974; Takeuchi & Nagao, 1993; Walther & Tidwell, 1995; Kasper-Fuehrer & Ashkanasy, 2001), this situation represents a shift in the way that trustfulness/trustworthiness develops in VTs.

Within Second Life people can purchase animations. These animations can be programmed to an avatar so that the avatar can act a certain way. For example, animations can be purchased to have your avatar dance with excitement or use interactive greetings such as shaking another's hand. Animations can also be set on the avatar so the avatar gracefully moves and sways when standing in a group conversing with others rather than just standing still with their hands on their hips.

Nonverbal cues were found to be an important communication tool within the groups and the type of nonverbal cues used was very similar to those used in face-to-face communication. To illustrate, consider the exchange that took place after my avatar accidently ran into another participant.

Participant1: "sorry about that, just ran into you"
Participant2: "LoL, it happens"
Participant3: "Yeah in SL you have to adjust to the concept of personal space being different lol"
Participant3: "people sometimes can't help it lol"
Participant2: "yes...but that shows how pervasive VWs can be...that we feel compelled to apologize when our pixels connect"

An example of the effect of nonverbal communication occurred in Group 4. During the initial meeting for Group 4 (Step 1), one of the avatars was wearing a watch. As the facilitator of the meeting, I was providing details about the project, offering a lot

of information to the group. I quickly noticed that the avatar wearing the watch continued to look at his watch several times throughout the meeting. Inferring on nonverbal cues in face-to-face communication, I associated this behavior with boredom or loss of interest. Not having met the avatar before, I began to worry that I was losing his interest in the meeting. As a result, I changed my communication style and began asking more questions of participants in order to engage all participants in the conversation.

Nonverbal communication seemed to play a role in Group 5 and may have contributed to lower levels of trustfulness/trustworthiness. This group had one person who did not interact well with others in the group. The avatar was very short with their responses and communication; she stood away from the rest of the group and did not participate in collaborative building efforts. During one of the group sessions, another participant in the group approached me in a private chat and asked if this particular avatar was planted on the team as a control mechanism.

> *Participant 1: "I want to ask you if anyone in the group is a 'plant' lol"*
> *Project Sponsor: "ha ha, nope."*
> *Participant 1: "I'm asking because, I *think* that the way Participant2 was behaving or at least the way I perceived her to be…it was off putting at first. I'm not shy at all and Participant3 seems arty and funny."*
> *Participant 1: "Basically, Participant 2 is a bit combative or at least appears that way."*
> *Participant 1: "In fact, I became friends with Participant 3, but didn't even think to offer it to Participant 2."*
> *Participant 1: "I thought perhaps Participant 2 was 'planted' to cause a wall.*
> *Participant 1: "It is very interesting how one person can affect a whole group."*

These examples support the idea that VWs are a more natural medium, they incorporate many of the elements of unencumbered face-to-face interaction (e.g., physical presence, ability to see and hear others, synchronicity) and is therefore perceived

as more natural for communication (MNT) (Kock, 2001). The data suggests that VWs have a high degree of naturalness and the degree of naturalness affects the development of trustfulness/trustworthiness. In this research, the technology was used to simulate nonverbal cues which were important in the development of trustfulness and trustworthiness.

There also seems to be a relationship between the degree of naturalness of the technology and one's embodied social presence. ESP allows individuals to experience a higher level of conveyance of social cues. Conveyance of social cues is a type of presence that relates to the degree to which any given medium has the capacity to transmit information that is perceived by a participant and used in the interpretation of the message (Lombard & Ditton, 1997). In the context of this research, the technology provided the capacity to transmit additional nonverbal communication cues that were perceived by the participants and used in the interpretation of the messages.

ESP may also be used to help explain the behavior of participants in Group 5, which fell in the low/low quadrant. One could argue that participants had a lower ESP and this affected group interaction which in turn had an effect on the development of trustfulness/trustworthiness. Alternatively, one could argue that participants had a high ESP. It is possible that the participants in Group 5 purposefully minimized their use of the capabilities or purposefully used them in a way to disengage from the group and this decreased trustfulness/trustworthiness. Finally, it is also possible that the individual in Group 5 who displayed "off putting" behavior was simply extending his or her identity into the virtual environment and the behavior presented in the VW was very similar to

their behavior in the real world. As such, this individual may also demonstrate low trustworthiness in face-to-face interactions. Future research is needed to explore this relationship further.

5.2.3.3 Immediacy of Artifacts

A third and final VWTC that offers interesting findings related to trustfulness and trustworthiness is immediacy of artifacts. Immediacy of artifacts is an ability to construct visual artifacts in the form of text, images, pictures, three-dimensional pictures, three-dimensional models, or some combination thereof in real time (Davis et al., 2009; Owens et al, 2011). Team members frequently leveraged this capability, building objects in an ad hoc way to demonstrate how things could work in their team's Rube Goldberg machine. Once someone had built an artifact, these objects frequently became the center of attention. People would move their avatars toward these items to interact with or comment on the object. Teams often had a collection of objects strewn about their work areas, some of which were incorporated into their final machines.

In face-to-face communication, when an individual wants others to visualize what they are talking about they may walk up to a white board and start drawing pictures. In a virtual world, immediacy of artifacts is similar; however, instead of drawing pictures the avatar can actually create objects and allow people to interact with those objects.

The teams that had increased levels of trust and met the project requirements had anywhere between five to ten objects in their work area at one time. Participants interacted with the objects and tweaked the objects before making a decision on whether or not to include them in the final machine. Group 2 had the most objects strewn about at

any given time. Group 1 was an exception, they did have increased levels of trust and met the project requirements, however, because each participant completed their work on their own prior to the meeting, they did not use this feature in the group setting. Group 5, a group that did not meet the requirements and had lower levels of trust had very few objects in their work area.

Immediacy of artifacts appeared to enhance collaboration by allowing participants to quickly build artifacts to visually show which skills they had to complete the project. This feature also provided an opportunity for participants to create three-dimensional diagrams of what they are describing and allowed others to interact with the objects.

5.3 Summary of Analysis and Results

This chapter presented the detailed results from study. Both qualitative and quantitative research findings were presented. These findings were discussed in relation to the research design and the research propositions. Overall, trustfulness and trustworthiness did increase during the study and both were influenced by the adaptation of VWTCs, specifically usage experience. A detailed discussion and interpretation of the research results based on these findings is presented in the next chapter.

CHAPTER 6: IMPLICATIONS, CONTRIBUTIONS, AND CONCLUSIONS

The focus of this research was on increasing our understanding of the dynamic nature of trust in virtual teams by examining the relationship between trustfulness, trustworthiness, and the adaptive use of VW technology capabilities. VTs rely heavily on technology to facilitate coordination, communication, and control in the team and technology can shape the way trust develops in those teams (e.g. Jarvenpaa et al., 1998; Jarvenpaa & Leidner, 1999; Hung, et al., 2004; Peters & Manz, 2007). This research has argued that VWs offer unique technology capabilities that have the potential to affect the development of trustfulness and trustworthiness in VTs. VWs offer a rich communication medium and provide support for three-dimensional visual representations of objects and people (Owens et al., 2010). VW technology capabilities (VWTCs) allow users the ability to mimic physical characteristics and actions of the real world. The visual cues, physical appearance, posture, gestures, body movements, and nonverbal cues used in the development of trust (Lea & Spears, 1995; Bacharach & Gambetta, 1997; Hung et al., 2004) are available to geographically dispersed teams using the capabilities offered in the virtual world. There have been many studies on trust in VTs; however, very few have studied the relationship between the adaptive use of VWTCs and the development of trustfulness and trustworthiness. A conceptual model was developed to help guide the research and proposed that there is a relationship between the way people adapt and use technology, specifically VW technology capabilities, and trustfulness/trustworthiness. A case based research study combining both qualitative and quantitative research methods was conducted to answer the overall research question.

The following sections discuss the implications of the research along with the expected contributions. The strengths and limitations of the research are also addressed followed by a discussion of possible future research.

6.1 Implications

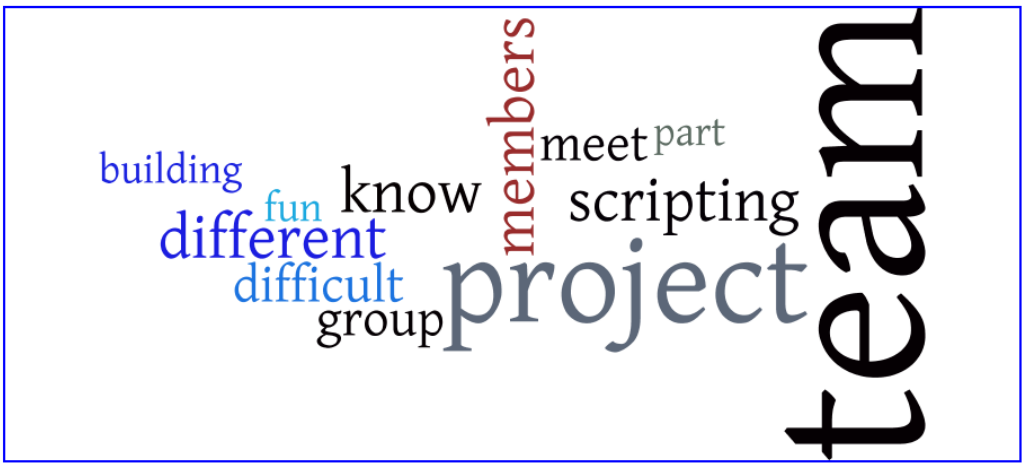
The results provide support for the conceptual model and indicate that there is a relationship between the adaptive use of VWTCs and trustfulness and trustworthiness. In the context of this research, VWs offered unique capabilities that allowed participants to represent themselves virtually and allowed them to use nonverbal communication cues, something that is often lost in other communication tools such as email and voice conferencing. While there were specific capabilities that offered unique insights, much of the power of the VWTCs emerged through the combination or interplay of capabilities. The research results reveal that these capabilities may in fact affect the development of trustfulness and trustworthiness; however, the results also reveal important information about VT interactions more generally.

The quantitative data revealed low correlation or significance in three of the five constructs; however, the qualitative data offered a more detailed, deeper explanation. Adaptive use of VWTCs is important and each group used the technology differently. However, most groups used it in a way that increased trustfulness and trustworthiness. Specific capabilities such as avatar appearance, nonverbal cues and gestures, and immediacy of artifacts seemed to be of the most significance.

On the post survey questionnaire, participants were offered the option of providing additional comments. As highlighted via the data visualization word frequency

cloud below, common phrases and themes persisted in the subjects' responses. These themes provide insights into the thoughts of the subjects as they reviewed the project post-completion. The frequency of words such as: "team", "members" and "groups" emphasizes the importance and interdependency of collaboration, while the high frequency of words such as "fun", "different" and "difficult" offer potential insights into the fit of the technology and capabilities to complete the task. This type of visualization provides guidance for analyzing the open ended responses and coding the responses into groupings that can be used for future analysis.

Figure 6.34. Word Cloud created using Post-Survey Open Ended Responses



The findings offer potential for leveraging the power of a visual, three-dimensional environment in order to build trust in VTs. The research results offer a new way of thinking about how to use immersive technology such as Second Life. Many people consider Second Life to be a massively multiplayer online role-playing game (MMORPG) and would not consider it for business applications, although there are several businesses and organizations that own land in Second Life (e.g. IBM, NASA, and

numerous universities). Second Life's CEO, Rod Humble describes it as a "shared creativity tool" or "creativity space" (Hindman, 2011). Many people who hear that are surprised by the description. Second Life is really a space where people can use their creativity to build and develop objects that do not exist in the real world. Most of the participants in this study were very familiar with Second Life's capabilities and were beyond the initial, steep learning curve. Each of the groups used the space as a shared creativity tool to develop a very complex Rube Goldberg machine, although given a very simple, basic set of requirements.

Immersive tools such as Second Life have a potential use in VT interactions; however, the challenge is finding the right task. As one participant pointed out, attending a lecture is not a good use of Second Life, but Second Life is great for interacting with others and for offering visual representations of ideas. The pilot study proved that having the right task was critical to the project. The task used in the pilot study required participants to collaborate on the creation of a project charter document. In that instance, Second Life was merely used as a voice conferencing tool; participants used the voice chat feature but none of the other capabilities. Second Life does not have support for shared text editors, therefore, participants used the audio chat feature to discuss the project charter while one person typed the information in a Word document. Based on findings from the pilot, the task for this research was changed to incorporate more of the features of Second Life.

On the post survey questionnaire participants were asked the following question: For the purpose of this project, what did you find was the most useful technology

capability in Second Life? With this data visualization word frequency cloud, the responses are focused on specific technology capabilities. These not only identify what capabilities within Second Life proved to be the most useful in completing the task, but also identify potential technology functions to target in future research in order to find the most effective capabilities that correlate to increasing trustfulness and trustworthiness in VTs.

Figure 6.35. Word Cloud Representing Most Useful VWTCs

Participants fit the technology in different ways to affect group performance and complete the task. The technology provided the needed capabilities to complete the steps in the project as evidenced by the complexity of the machines. The findings highlight the importance of task/technology fit in relation to team outcomes. Additionally, the findings suggest that the inclusiveness of the technology in relation to the task work together to create a desired outcome. The capabilities unique to VWs were sufficient for each of the steps in the project. Some steps were more complex than others and participants used

multiple capabilities to complete those steps. In completing the project, each team relied solely on the capabilities offered by the VW; they did not look to outside capabilities to complete the project. For example, people used only the communication tools available within Second Life even though email and other communication tools were available.

The research results also offer a new way of thinking about who is using such immersive technology. People often think about the users of immersive technology as young gamers, however, the participants used in this study did not fit that stereotype. Second Life has a diverse community of residents. The participants that participated in the research study were recruited randomly from within Second Life and the population used in the study was higher in age than what was expected, providing evidence contrary to the young gamer stereotype. The data collected also suggested that people were comfortable with the technology (they did not have to learn it) and this allowed them to focus on the project, rather than focus their efforts on learning the technology.

VW technology can be considered a more natural medium as defined by Media Naturalness Theory (MNT) (Kock, 2001). In the context of this research, the technology provided opportunities for people to change their avatar's appearance and control their avatar's behavior. The technology also provided ways for avatars to demonstrate their ideas, bring their words to life by creating objects for others to view and see (immediacy of artifacts). One could argue that the naturalness of the technology drew participants in creating an embodied social presence (ESP) (Mennecke, 2011). The technology was used to simulate nonverbal cues and to transmit information that was used in the interpretation of messages and interactions.

6.2 Strengths and Limitations of the Research

Every research has its own strengths and weaknesses. The following sections present the strengths and limitations of this research.

6.2.1 Strengths of the Research

This study builds on prior research on trust in VTs in order to advance understanding of how VW technology affects the development of trustfulness and trustworthiness in VTs. The focus on immersive VW technology provides a step forward in the area of research related to VW technology. The model of the adaptive use of VW technology capabilities and its relation to trustfulness and trustworthiness was presented and evaluated.

A major strength of this research is the mixed methods approach to the research design, combining both qualitative and quantitative data. The qualitative data provided depth and context to the quantitative data. The quantitative data could be reviewed carefully against what was happening in each case study or group. The qualitative data, therefore, helped to explain the quantitative results and offer additional support for or against the quantitative results.

An additional strength of the research was with regard to the research design which allowed for the collection of multiple data sources. There was a plethora of data available for review. There were pre and post surveys for each individual, each group meeting was recorded using video recording software and each communication item was recorded in a text log file. One of the advantages of this approach was that the researcher had the ability to go back and review these data sources over and over again, without

losing context or details. However, the sheer amount of data also presented a challenge. Because there was so much data it was easy to get overwhelmed and distracted from the overall research goal.

The way that trust was defined in the study presents another strong point of the research. Trust is a complex concept and requires careful analysis and definition. The layered approach to defining trust and its related concepts was a unique approach that aided in the understanding of which dimensions of trust were being used in this study. It also helped when choosing appropriate measures for each dimension of trust. Some prior research studies on trust use one construct to measure trust, however, the measures they use assess different aspects of trustfulness and trustworthiness. For example, some studies combine cognitive and affective measures, measures of trustfulness, with measures of integrity and ability, measures of trustworthiness. Additionally, some studies combine measures of personality based trust with measures of cognitive and affective measures. By understanding the various dimensions and components of trust, this allowed for the careful and accurate measure of each of specific components in the study.

A final strength relates to the case study approach of the research design. Case studies are the preferred method when *how* or *why* questions are being posed and when the focus is on a contemporary phenomenon within a real-life context (Yin, 2009). The case method allows the question of *why* and *how* rather than just *what* to be answered with a relatively full understanding of the nature and complexity of the complete phenomenon (Benbasat et al., 1987). In the context of this research, the case study

design was a good approach to address the research question which asked *how*. Another strength of case study research is that the phenomenon can be studied in its natural setting and meaningful, relevant theory generated from the understanding gained through observing actual practice (Benbasat, Goldstein, & Mead, 1987). Advantages of case study research include the richness of its explanations and its potential for testing hypotheses in well-described, specific situations (Eisenhardt, 1989).

6.2.2 Limitations of the Research

Several limitations of this study can be identified, primarily due to the exploratory nature of the research. First, one of the limitations relates to how often trustfulness and trustworthiness were measured in the study. After initial review of the data, it was identified that measuring trustfulness/trustworthiness at additional points in the study would help determine specific points in the study where these constructs changed. For example, measuring trust in between each step in the project may have been helpful in understanding key events that affect the development of trustfulness/trustworthiness. Additionally, the survey did not measure trustfulness or trustworthiness in relation to others. It may have also been helpful to measure trust in relation to others.

Second, the study did not consider the effect of culture on trustfulness or trustworthiness. Culture may play a role in the development of trustfulness and trustworthiness; however, the study did not examine this potential effect. The study also did not address the potential impact of organizational trust on individual trustfulness/trustworthiness. For example, in many VTs, people come together to

complete a project, however, these people often work for the same organization. Therefore, these individuals have a level of organizational trust that affects the development of individual trustfulness/trustworthiness. The teams used in this study were ad hoc VTs that did not work for a particular organization; therefore, they did not have a certain level of organizational trust. Therefore, when applying the use of VWTCs to a business context, one might need to consider the effect of organizational trust. This may also be an area of future research.

A third area deserving attention involves the way that fit was measured in the study. Fit is the ideal use of a capability or set of capabilities that affect group performance. However, the items used to measure fit did not align well with this definition. The items were based on a more recent study of fit (Sun & Frike, 2009) that focused more on the repurposing of capabilities.

A fourth consideration is in relation to embodied social presence theory. Embodied presence creates an opportunity for the individual to develop and extend his or her identity in the virtual environment and this can help people create an identity for themselves, identify with others, and promote the development of trust. The research study offers support for the relationship between ESP and the development of trustfulness/trustworthiness. However, the study did not measure one's level of presence one had. Future research could look at the relationship between ESP and levels of trust and measure ones level of embodied social presence.

Finally, the study suffers from the common criticisms of case study research. Some of the difficulties of doing case research are the requirements of direct observation

in the actual situation which include cost, time, and access hurdles. However, many of these challenges were addressed by using various data collection methods. Another difficulty is the need for multiple methods, tools, and entities for triangulation, the lack of controls, and the complications of context and temporal dynamics. Again, the study attempted to address these difficulties by combining multiple sources – both qualitative and quantitative. Another serious disadvantage of the case method is the lack of familiarity of its procedures and rigor by our others (Meredith, 1998). For example, Aldag and Stearns (1988) (p. 260–261) point out that "qualitative research in general is commonly perceived as exhibiting a tendency for construct error, poor validation, and questionable generalizability".

6.3 Contributions

The results of this study provide insight into the way VW technology capabilities are used in group interaction. The research results have relevance in theoretical and applied understanding of VTs. The study also offers a contribution in the way trust is defined and measured.

6.3.1 Contributions to Research

This study offers several contributions to research. First, the conceptual model that was developed in Chapter 3 is the first outcome of the study. The conceptual model highlights the importance of the adaptive use of VWTCs. It is not just the use of technology capabilities that is important, but the way individuals adapt and use the technology capabilities. The model was developed in the spirit of the social-technical view of work practices and highlights the relationships between the social components –

trustfulness and trustworthiness – and the technical components. Prior research in VWs as highlighted the importance of the interplay between the social and technical components of work processes, and it is the interplay that affects team processes (Owens et al., 2010). This research adds support for this notion by emphasizing the relationship between the social and technical components and the development of trustfulness and trustworthiness in the team.

Second, the research offers a contribution to the literature in the way that trust is defined. There have been several studies on trust in VTs (42 empirical studies over an 11 year period, Mitchell & Zigurs, 2009); however, there are inconsistencies in the literature with regard to trust concepts. This dissertation research attempts to address these inconsistencies by using a layered approach to define trust and its related components. The layered approach was a unique approach that aided in the understanding of the various dimensions of trust and helped clarify the specific dimensions of trust relevant to this study. This study separated trust into two components – trustfulness and trustworthiness. The layered approach also offers a starting point for adding clarity and specificity to future research studies on trust. Additionally, this study was unique in that it did not combine multiple dimensions of trust, but kept them as separate constructs.

Third, the study offers a new way to look at technology capabilities and to measure the way specific capabilities are used. This study provided a way to quantitatively measure the adaptive use of VWTCs. The measures used in this study could also be used to measure the adaptive use of other technology capabilities. The ability to quantitatively measure the use of technology capabilities was important in this

study by offering a way to understand how the adaptive use of VWTCs affected the development of trustfulness and trustworthiness.

Next, the study offers support for prior theoretical work on trust and virtual teams. First, this research adds support to the McKnight model of trust (McKnight et al., 1998) specifying that personality-based trust affects individual trust levels within a team. One develops beliefs about another's individual trustworthiness based on interpersonal factors and factors related to the situation rather than the trustee's behavior (McKnight et al., 1998). This research adds support to this view. The data revealed high levels of initial trustfulness and trustworthiness in some groups. Second, this research adds support for TTF theory suggesting that "an appropriate task/technology fit should result in higher performing groups (Zigurs & Buckland, 1998, p. 325)". While group performance was not a construct or a direct measure in this study, performance was measured by whether or not the groups completed the requirements of the project. The way the individuals fit the technology in relation to the task resulted in most teams delivering a project that met or exceeded the requirements. With regard to fit, the study found that the way fit is traditionally measured may not be appropriate especially when the technology is already a good fit for the task. This presents opportunities for addressing fit in a new way. Third, this research adds support for Embodied Social Presence (ESP) theory (Mennecke, 2011) and creates an opportunity to extend the theory with relation to trustfulness/trustworthiness. An embodied presence creates an opportunity for an individual to create and extend their identity into the virtual environment and this can help people create an identity for themselves, identify with others, and promote the

development of trust. Fourth, this research offers support for Media Naturalness Theory (MNT) (Kock, 2001) creates an opportunity to extend the theory with relation to trustfulness/trustworthiness. Media that incorporates the elements of unencumbered face-to-face interaction will be perceived as more natural for communication than other media; therefore, the extent to which a communication medium incorporates face-to-face interaction elements defines its degree of naturalness. VWs provide a high degree of media naturalness and this high degree of media naturalness affected the development of trustfulness/trustworthiness in VTs. The high degree of naturalness offered the ability for participants to communicate in a way to reduce cognitive load, allowing for the ability to use visual cues (physical appearance, posture, gestures, body movements, and nonverbal cues) to develop trust.

Finally, the research design presented and used in this study offers a unique approach by combining multiple data sets. Both quantitative and qualitative data was captured and reviewed together to present an entire picture of what is happening in each group or case. These various data points provided a holistic view into what was happening in each group. It was helpful when interpreting the quantitative results and offered a better understanding of how VWTCs were utilized within the teams. There is also the potential for considering the use of VWs in future research. VWs provide the ability to record and store all group interactions for later use and analysis. This creates a suitable environment for data intensive research projects.

The following table summarizes the major contributions of the research.

Table 6.23. Contributions

Prior Research	Gap in Prior Research	Contribution
Several studies on trust in VTs (42 empirical studies over an 11 year period) (Mitchell & Zigurs, 2009).	Inconsistency in the way trust is conceptualized and operationalized.	Offers clarity to the way trust is defined and operationalized. In this study, trust was defined by trustfulness and trustworthiness.
	Conceptualization and Operationalization of the way individuals use technology capabilities (adaptive use of technology capabilities)	This study provided a way to quantitatively measure the way individuals use technology capabilities, specifically, VWTCs.
Personality-based trust affects individual trust levels within a team. (McKnight et al., 1998).		This research adds support to this view. The data revealed high levels of initial trustfulness and trustworthiness in some groups.
Task-Technology Fit (TTF) – an appropriate task/technology fit results in higher performing teams (Goodhue & Thompson, 1995).		This research adds support for TTF suggesting that "an appropriate task/technology fit should result in higher performing groups (Zigurs & Buckland, 1998, p. 325)".
Technology Acceptance Model (TAM), -participants' degree of acceptance of new technology is an additional factor in effective collaboration. Acceptance is the individual's decision about how and when they will use technology (Davis, 1989).		Adds support for TAM. Participants in the study were experienced with the technology and accepted the technology, which affected the development of trustfulness/trustworthiness in the teams.
Socio-technical view of work processes - it is the interplay between the social and technical components of work processes that affects team processes (Owens et al., 2010).		Adds support for the socio-technical view of work processes. The interplay between the social and technical processes that affects team processes and the development of trustfulness and trustworthiness in the team.
Embodied Social Presence (ESP) – the body is the center of communication and an embodied representation such as an avatar affects the perceptions of individuals by drawing them into a higher level of cognitive engagement in their shared activities and communication acts (Mennecke, 2011).	Little prior research relating to ESP and trust levels.	This research adds support for ESP theory. An embodied presence creates an opportunity for an individual to create and extend their identity into the virtual environment and this can help people create an identity for themselves, identify with others, and promote the development of trust.

Table 6.23. Contributions – Continued

Prior Research	Gap in Prior Research	Contribution
Media Naturalness Theory (MNT) – media that incorporates the elements of unencumbered face-to-face interaction will be perceived as more natural for communication than other media, therefore, the extent to which a communication medium incorporates face-to-face interaction elements defines its degree of naturalness (Kock, 2001).	Little prior research on the relationship between the level of media naturalness of a given technology and the way one adapts technology, and the development of trust.	VWs provide a high degree of media naturalness and this high degree of media naturalness affected the development of trustfulness/trustworthiness in the teams used in this study.
In face-to-face communication, individual appearance plays a role in trust (Lea & Spears, 1995).	Little prior research exploring the effect of avatar appearance on trust.	Rendering capabilities offered by VWs provide an opportunity for people to customize their avatar's appearance, which may have played a role in the development of trustfulness/trustworthiness in this study.

6.3.2 Contributions to Practice

On a practical level, the study indicates that there is value in using VWTCs in VTs to develop trust. From the results of the study, we may impart important guidelines for using VWTCs in a way that maximizes the development of trustfulness/trustworthiness in VTs. This information could be useful as organizations continue to rely on VTs to complete projects. For example, the results suggest that when considering the use of VWs in VT interaction, one should consider the task and the purpose. When people are thrown into a VW environment without a clear purpose or clear guidelines they will struggle. Managers of VTs should carefully consider their approach to integrating VWs into their teams and carefully consider the task. VWs are good for creating things and visualizing ideas, therefore, new product development tasks may be a good fit. Team building exercises would be a good way to utilize VW technology in a way to also increase trustfulness/trustworthiness. Tasks that do not

require this same level of interaction and immersiveness may not be a good fit. For example, creating and editing a document together may, or attending a meeting together to get a project update may not be a good task fit. These results may also have implications for design of next generation collaboration systems that incorporate VWTCs.

6.4 Future Research

There is still much to explore with regard to how teams interact in a virtual world. During the analysis and results of the research specifically, many questions and ideas were considered relating to future research For example, there are opportunities for further exploration of the interrelationships between fit, inclusiveness, usage experience and trustfulness/trustworthiness. Based on the data collected, additional evidence is needed to fully support or oppose the propositions relating to these constructs.

There are opportunities for re-examining the concept of fit. Fit is the ideal use of a capability or set of capabilities that affect group performance. However, the items used to measure fit did not align well with this definition. The items were based on a more recent study of fit (Sun & Frike, 2009) that focused more on the repurposing of capabilities. Therefore, future research may be needed in order further explore the relationship between fit and trustfulness/trustworthiness using more appropriate measures of fit.

Additionally, the data collected suggests there is indirect evidence to suggest that that the use of rendering and interaction capabilities affects trustfulness/trustworthiness. Specifically, avatar appearance, nonverbal cues, and immediacy of artifacts could be

potential areas of future research. For example, does avatar appearance directly affect the development of trustfulness or trustworthiness? A study that controlled for avatar appearance could yield additional insight into this relationship. Another question to consider relates to nonverbal cues. Does the use of nonverbal cues facilitate the development of trustfulness or trustworthiness? Are there certain cues that actually counteract their development? Similarly, a study that controls the nonverbal cues used in communication would be a potential way to study this relationship.

Another area of future research relates to age. In the study, over 50% of the participants were over 40 with 36% of participants being 52 or older. This was unexpected given the immersive nature of the technology. This presents an interesting area of future research to explore why the study had such a large percentage of participants in the 52 or older age group. Additionally, future research could explore the relationship between age and trustfulness/trustworthiness. Does age have an effect on initial or post levels of trustfulness/trustworthiness?

We know that over time trust will develop in VTs to meet the same levels as face-to-face teams (Wilson et al., 2006). Do VWs provide an opportunity for trust to develop more quickly? Future work could compare various data sets, one using VW technology, one using other technology, and one face-to-face group. Future research might measure levels of personality based trust and organizational trust in order to determine what level of trust a person has prior to beginning the project. This would be helpful in understanding the external factors that affect the development of trustfulness and trustworthiness.

Finally, it is also possible that the individual in Group 3 who displayed "off putting" behavior was simply extending his or her identity into the virtual environment and the behavior presented in the VW was very similar to their behavior in the real world. As such, this individual may also demonstrate low trustworthiness in face-to-face interactions. Future research is needed to understand the relationship between real world and in world presence further. An example proposition might be – *Higher levels of embodied social presence result in higher levels of trustfulness and trustworthiness.*

6.5 Conclusion

This dissertation presented a discussion of the theoretical background and research method for addressing the research question: *How does the use of virtual world technology capabilities affect the development of trust in virtual teams?* The study is new in that very few studies have explored the relationship between the adaptive use of VWTCs and the development of trustfulness and trustworthiness. A conceptual model was developed to help guide the research and proposed that there is a relationship between the way people adapt and use technology, specifically VW technology capabilities, and trustfulness/trustworthiness. The results of this study add to the literature on virtual teams, trust, the adaptive use of technology, and virtual world technology.

APPENDICES

APPENDIX A: KEY DEFINITIONS

ability: the aptitude and skills that enable an individual to be perceived as competent by teammates.

adaptive use (adaptation): a) the degree to which users exploit and explore capabilities in a given context, b) the degree to which intended capabilities are used, modified, changed, or complemented and c) the extent to which new capabilities are discovered with a given technology. The goal of adaptively using technology capabilities in a given context is to find a perfect fit between tasks and technologies.

affective trust: based trust involves one's emotional bonds and sincere concern for the well-being of the others.

awareness: an ability for users in the world to participate synchronously and provide a sense of being there.

benevolence: the extent to which an individual is believed to be willing to help teammates beyond personal motives or individual gain.

cognitive trust: develops from social cues and impressions that an individual receives from others.

communication support: communication and collaboration through the use of feedback, multiplicity of cues and channels, language variety, channel expansion, and communication support.

communication effectiveness: the ability to achieve the desired communication outcome; the intended or expected communication effect.

fit: a facilitator in the process of IT adaptation where ideal profiles composed of an internally consistent set of task contingencies and GSS elements that affect group performance.

inclusiveness: is the extent to which an individual embraces and utilizes the diverse capabilities provided by the technology.

institution-based trust: trust based on the norms and rules in the institution .

integrity: the extent to which an individual is believed to adhere to a set of principles thought to make her dependable and reliable.

interaction: support the process of people and avatars working together with others and engaging with the virtual world environment.

interpersonal trust: an expectancy held by an individual or a group that the word, promise, verbal or written statement of another individual or group can be relied upon.

personality-based trust: trust based on one's disposition to trust that is formed based on a person's trusting nature.

project outcomes: the outputs for the specific project and can be both task and team-related outcomes.

rendering: support the process of creating life-like images such as avatars and objects in the virtual world environment. Specific capabilities include personalization and vividness of representation that utilizes 2D and immersive 3D imagery.

team process: support the team processes such as process structure, information processing, appropriation support, socialization/community building.

trust: a psychological state involving vulnerability under conditions of risk where an individual has an expectation of another's motives, ability, and or fair behavior irrespective of the ability to monitor or control the other party.

trustfulness: one's willingness to depend on another in a given situation.

trustworthiness: one's belief that another person is benevolent, competent, honest or predictable in a situation.

usage experience: the user's experience with using and interacting with technologies.

virtual team: a group of individuals that come together for a specific goal or completion of a specific project, are dispersed geographically, temporally, culturally, and/or organizationally, and rely predominantly on information technology to communicate and interact with each other.

virtual world: a metaverse environment that offers a synchronous, persistent network of people, represented as avatars, facilitated by networked computers.

virtual world technology capabilities: distinctive features of virtual worlds including various technological functionalities that offer a potentiality or undeveloped potential that are dynamic, representing a starting point that can change through interaction in a the environment.

APPENDIX B: DEFINITIONS OF VIRTUAL TEAMS

Table A.22. Definitions of Virtual Teams

Definition	Attributes	Citation
Groups of geographically, organizationally, and/or time dispersed workers brought together by information and communication technologies to accomplish one or more organizational tasks	Geographic dispersion Temporal dispersion Organizational dispersion Utilize technology for communication	Alavi & Yoo (1997); Desanctis & Poole (1997); Jarvenpaa & Leidner (1999); Powell, Piccoli, & Ives (2004)
A group of people striving toward a common goal, dispersed in many locations, communicating with each other predominantly via information and communication technology	Common goal Geographic dispersion Utilize technology for communication	Axtell, Fleck, & Turner (2004); Gibson & Gibbs (2006)
Assembled on an as needed basis to cooperate on specific deliverables, or to fulfill specific customer needs	Assembled as needed Fulfill specific deliverables or customer needs	Chase (1999)
Groups of geographically and/or temporally dispersed individuals brought together via information and telecommunication technologies	Geographic dispersion Temporal dispersion Utilize technology for communication	DeSanctis & Poole (1997); Jarvenpaa & Leidner (1999); Lipnack & Stamps (1997); Powell et al. (2004)
Can be temporary and focused on the completion of a specific project, can be long lasting, with stable membership over several months or years	Temporary or long lasting Focused on a specific project (common goal)	Duarte & Snyder (1999); Lipnack & Stamps (1997); Townsend et al. (1998)
Virtual teams are dispersed at least geographically, and potentially on other dimensions, and rely on collaboration technologies for interaction	Geographic dispersion Utilize technology for collaboration	Dubé & Paré (2004)
A group of people who interact through interdependent tasks guided by common purpose and work across space, time, and organizational boundaries with links strengthened by webs of communication technologies	Interdependent tasks Common goal Geographic dispersion Temporal dispersion Utilize technology for communication	Lipnack & Stamps (1997)
Identified by their organizations and members as a team, are responsible for making and/or implementing decisions important to the organization's global strategy, use technology supported communication substantially more than face-to-face communication and work and live in different countries	Member of an organization Make and/or implement decisions relating to organizational global strategy Geographic dispersion Utilize technology for communication	Maznevski & Chudoba (2000)
Project teams that rapidly form, reorganize, and dissolve when the needs of the workplace change. Includes individuals with differing competencies located across time, space, and cultures	Rapidly form and dissolve Different competencies Geographic dispersion Temporal dispersion Cultural dispersion	Mowshowitz (1997)
Teams with preponderant and at times	Utilize technology for	Powell, Piccoli, & Ives

exclusive reliance on IT to communicate with each other, their flexible composition, and their ability to traverse traditional organizational boundaries and time constraints	communication Flexible Temporal dispersion Organizational dispersion	(2004)
People whose interaction is mediated by different information technologies (e.g. email, videoconferencing, groupware), which allow them to work together while separated across space and time	Interaction mediated by technology. Technology dispersion Geographic dispersion	Rico, Alcover, Sanchez-Manzanares, & Gil (2009)
Intended to map to a workplace team and its members should have the same kinds of setup as the workplace such as the same kinds of prior engagement and forms of hierarchies	Map to a workplace team Similar in setup to a workplace team	Williams (2010)
Mediated by technology, though the specific medium can range from e-mail to a fully immersive three-dimensional environment. Different media are appropriate for different types of organizational tasks	Mediated by technology appropriate for the task	Anderson, Taylor, Dossick, Neff, Iorio (2011).

APPENDIX C: IRB APPROVAL

University of Nebraska Medical Center

NEBRASKA'S HEALTH SCIENCE CENTER

Office of Regulatory Affairs (ORA)
Institutional Review Board (IRB)

June 28, 2011

Dawn Owens
College of Information Science and Technology
UNO – Via Courier

IRB#: 318-11-EX

TITLE OF PROTOCOL: Understanding the Adaptive Use of Virtual World Technology Capabilities and Trust in Virtual Project Terms

Dear Ms. Owens:

The Office of Regulatory Affairs (ORA) has reviewed your application for ***Educational, Behavioral, and Social Science Research*** on the above-titled research project. According to the information provided, this project is exempt under 45 CFR 46:101b, category 2. You are therefore authorized to begin the research.

It is understood this project will be conducted in full accordance with all applicable HRPP Policies. It is also understood that the ORA will be immediately notified of any proposed changes that may affect the exempt status of your research project.

Please be advised that this research has a maximum **approval period of 5 years** from the original date of approval and release. If this study continues beyond the five year approval period, the project must be resubmitted in order to maintain an active approval status.

Sincerely,

Gail D. Kotulak

Gail Kotulak, CIP
IRB Administrator
Office of Regulatory Affairs (ORA)

gdk

APPENDIX D: PRE AND POST SURVEYS

Virtual World Project – Pre-Survey

Please answer all questions as best as you can.

Statement					
Background Questions					
Please indicate your gender.	M	F			
Please choose your age range.	18-26	25-33	34-42	43-51	52 or older
Have you ever worked with Virtual World Technology?	Y	N			
How often do you use technology to complete tasks in your daily job?	Continuously	2-3 hours a day	A few hours every other day	Rarely	Never
Describe your comfort level with new technology.	Very comfortable	Comfortable after spending a little time with the technology	Comfortable after formal training	Appre-hensive	Not comfortable
List three technologies that you use most often for collaborating with friends and co-workers.	1. 2. 3.				

Please place a check mark in the box that most closely describes your opinion about your upcoming experience on your team project using Second Life.

Statement	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
I believe we will have a sharing relationship on the team, we will be able to share our ideas and feelings					
I will be able to talk freely to the team about difficulties with the project; I know they will listen.					
If I share my problems with the team, I know they will respond constructively and caringly.					
Other team members will approach the project with professionalism and dedication.					
I can rely on the team not to make the project more difficult by careless work.					
If I have my way, I won't let other team members have influence over issues that are important to the project.					
I feel comfortable depending on my team for the completion of the project.					
I feel that my team members will be honest with me.					

I am comfortable letting other team members take responsibility for tasks which are critical to the project even if I cannot monitor them.					
Members of my team will show a great deal of integrity.					
I will be able to rely on those with whom I work with in this team.					
Overall the people in my team will be trustworthy.					
We will be considerate of one another's feelings in this team.					
The people in my team will be friendly during the project.					
We will have confidence in one another in this team.					
Using the capabilities provided by the technology will improve my performance.					
Using the capabilities provided by the technology will increase my productivity.					
Using the capabilities provided by the technology will enhance my effectiveness.					
Considering all tasks, the capabilities will be useful for in completing this project.					
The technology will have the capabilities required for our tasks.					
The technology will have the overall capabilities I need.					
I will use some capabilities together for the first time.					
I will combine capabilities with other capabilities to finish a task.					
I will not hesitate to use a capability because it is favored over the one I am using.					
I may apply some capabilities to tasks that the capabilities were not meant for.					
I may use capabilities in ways that were not intended to be used.					
The developers of the technology will probably disagree with how I will use certain capabilities.					
I may use some capabilities in a way at odds with its original intent.					
I may invent new ways of using some of the capabilities to complete a task.					
I may create work arounds to overcome system restrictions.					
Additional Comments:					

Virtual World Project – Post-Survey

Please place a check mark in the box that most closely describes your opinion about your experience on your team project using Second Life.

Statement	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
We had a sharing relationship on the team, we were able to share our ideas and feelings					
I was able to talk freely to the team about difficulties with the project; I knew they would listen.					
If I shared my problems with the team, I know they would respond constructively and caringly.					
Other team members approached the project with professionalism and dedication.					
I relied on the team not to make the project more difficult by careless work.					
If I had my way, I wouldn't have let other team members have influence over issues that were important to the project.					
I felt comfortable depending on my team for the completion of the project.					
I felt that my team members were honest with me.					
I was comfortable letting other team members take responsibility for tasks which were critical to the project even when I could not monitor them.					
Members of my team showed a great deal of integrity.					
I can rely on those with whom I worked with in this team.					
Overall the people in my team were trustworthy.					
We were usually considerate of one another's feelings in this team.					
The people in my team were friendly during the project.					
We had confidence in one another in this team.					
Using the capabilities provided by the technology improved my performance.					
Using the capabilities provided by the technology increased my productivity.					
Using the capabilities provided by the technology enhanced my effectiveness.					
Considering all tasks, the capabilities were useful for in completing this project.					
The technology had the capabilities required for our tasks.					
The technology had the overall capabilities I needed.					

I used some capabilities together for the first time.					
I combined capabilities with capabilities to finish a task.					
I did not hesitate to use a capability because it was favored over the one I was using.					
I applied some capabilities to tasks that the capabilities were not meant for.					
I used some capabilities in ways that were not intended to be used.					
The developers of the technology would probably disagree with how I used certain capabilities.					
I used some capabilities in a way at odds with its original intent.					
I invented new ways of using some of the capabilities to complete a task.					
I created work arounds to overcome system restrictions.					
Additional Comments:					

Please answer the questions as best as you can.

Statement					
How much communication and coordination took place outside of Second Life?	Less than 1 hour	1-2 hours	2-3 hours	3-4 hours	More than 4 hours
List any other technologies you used for communication and collaboration (i.e. email, blackboard group discussion board, etc).	1. 2. 3. 4.				

APPENDIX E: DETAILED STATISTICS

One-way ANOVA using post measures of trustfulness, usage experience, inclusiveness, and fit.

ANOVA – Trustfulness (Post)

		Sum of Squares	df	Mean Square	F	Sig.
Usage Experience Post Mean	Between Groups	4.535	12	.378	1.166	.403
	Within Groups	3.567	11	.324		
	Total	8.102	23			
Inclusiveness Post Mean	Between Groups	1.817	12	.151	.525	.858
	Within Groups	3.173	11	.288		
	Total	4.990	23			
Fit Post Mean	Between Groups	4.352	12	.363	1.007	.499
	Within Groups	3.961	11	.360		
	Total	8.313	23			
Adaptive Use Post Mean	Between Groups	2.411	12	.201	1.372	.304
	Within Groups	1.611	11	.146		
	Total	4.022	23			

One-way ANOVA using post measures of trustworthiness, usage experience, inclusiveness, and fit.

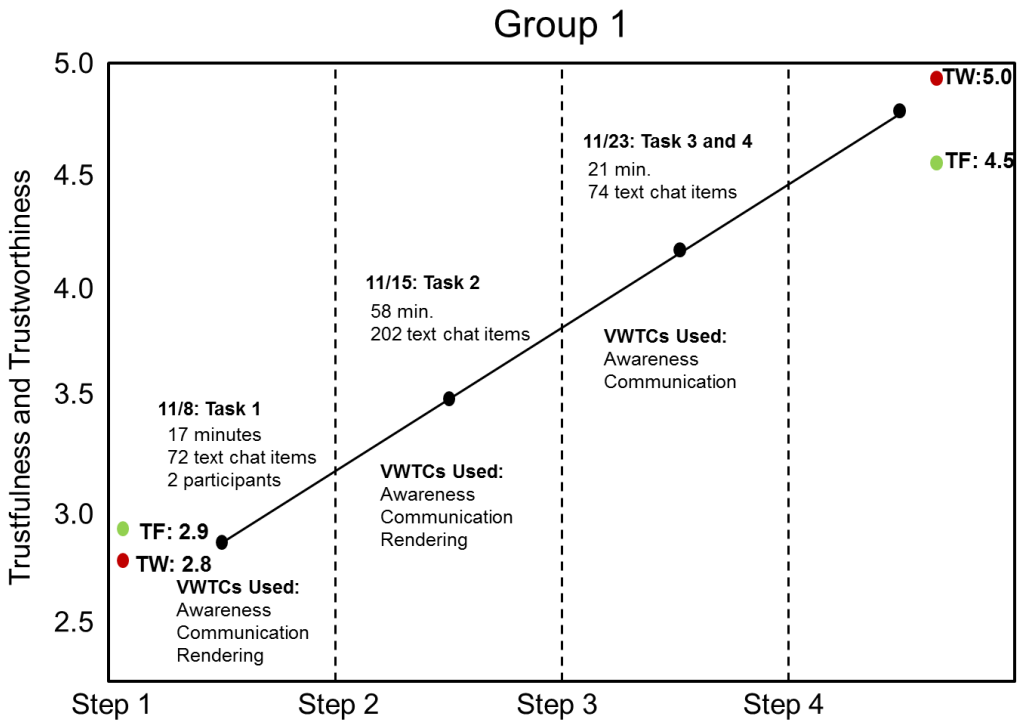
ANOVA – Trustworthiness (Post)

		Sum of Squares	df	Mean Square	F	Sig.
Usage Experience Post Mean	Between Groups	3.745	9	.416	1.337	.302
	Within Groups	4.356	14	.311		
	Total	8.102	23			
Inclusiveness Post Mean	Between Groups	1.783	9	.198	.865	.575
	Within Groups	3.206	14	.229		
	Total	4.990	23			
Fit Post Mean	Between Groups	3.893	9	.433	1.370	.288
	Within Groups	4.420	14	.316		
	Total	8.313	23			
Adaptive Use Post Mean	Between Groups	1.488	9	.165	.913	.541
	Within Groups	2.534	14	.181		
	Total	4.022	23			

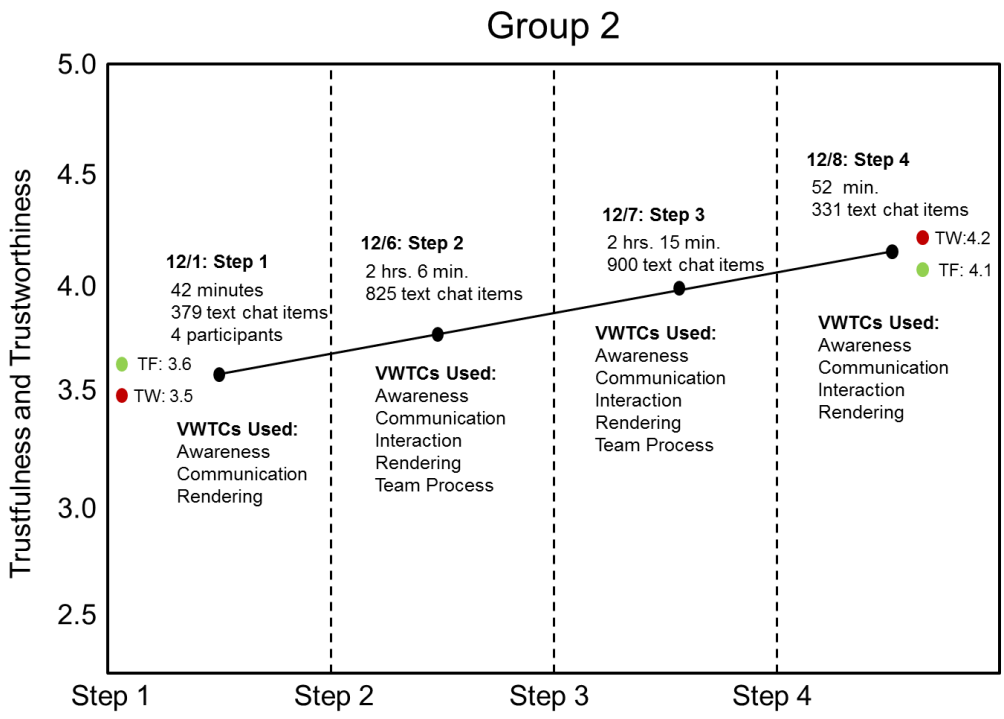
APPENDIX F: TEXT CHAT LOG DETAILS

		Task 1	Task 2	Task 3	Task 3 Mtg 2	Task 4	Totals
Group 1	start time	11/8/11 12:06 PM	11/15/11 12:02 PM	11/23/11 12:06 PM	NA	Task 3 and 4	
	end time	11/8/11 12:23 PM	11/15/11 1:00 PM	11/23/11 12:27 PM		were combined	
	total time	17 min.	58 min.	21 min.			1 hr. 36 min.
	# of chat items	72	202	74	NA		348
Group 2	start time	12/1/11 12:10 PM	12/6/11 5:55 PM	12/7/11 6:59 PM		12/8/11 7:07 PM	
	end time	12/1/11 12:52 PM	12/6/11 8:01 PM	12/7/11 9:14 PM		12/8/11 7:59 PM	
	total time	42 min.	2 hrs. 6 min.	2 hrs. 15 min.		52 min.	5 hrs. 55 min.
	# of chat items	379	825	900		331	2,435
Group 3	start time	12/7/11 7:22 PM	12/8/11 6:00 PM	12/12/11 5:57 PM	12/15/11 6:28 PM	12/19/11 6:12 PM	
	end time	12/7/11 8:05 PM	12/8/11 7:07 PM	12/12/11 7:03 PM	12/15/11 8:28 PM	12/19/11 6:53 PM	
	total time	43 min.	1 hr. 7 min.	1 hr. 6 min.	1 hr. 56 min.	41 min.	5 hrs. 33 min.
	# of chat items	249	449	479	871	289	2,337
Group 4	start time	1/26/12 5:59 PM	1/31/12 5:58 PM	2/6/12 6:00 PM	NA	2/9/12 6:50 PM	
	end time	1/26/12 6:59 PM	1/31/12 7:28 PM	2/6/12 8:30 PM		2/9/12 8:31 PM	
	total time	1 hr.	1 hr. 30 min.	2 hrs. 30 min.		1 hr. 41 min.	6 hrs. 41 min.
	# of chat items	233	359	703		304	1,599
Group 5	start time	2/12/12 11:53 AM	2/15/12 9:05 AM	2/20/12 9:54 AM	2/23/12 10:00 AM	2/24/12 10:00 AM	
	end time	2/12/12 1:02 PM	2/15/12 11:25 AM	2/20/12 12:08 PM	2/23/12 11:53 AM	2/24/12 11:03 AM	
	total time	1 hr. 9 min.	2 hrs. 20 min.	2 hrs. 12 min.	2 hrs. 53 min.	1 hr. 3 min.	9 hrs. 37 min.
	# of chat items	303	317	365	262	229	1,476
Group 6	start time	4/9/12 10:26 AM	4/12/12 10:30 AM	4/14/12 10:24 AM	4/18/12 10:29 AM	4/20/12 11:28 AM	
	end time	4/9/12 11:10 AM	4/12/12 12:40 PM	04/14/12 12:06 PM	4/18/12 11:44 AM	4/20/12 11:48 AM	
	total time	44 min.	2 hrs. 10min.	1 hr. 30 min.	1 hr. 15 min.	20 min.	5 hrs. 59 min.
	# of chat items	196	125	437	304	201	1,263
Group 7	start time	4/11/12 10:53 AM	4/13/12 10:53 AM	4/19/12 10:30 AM	NA	4/23/12 10:55 AM	
	end time	4/11/12 11:53 AM	4/13/12 12:16 PM	4/19/12 11:40 AM		4/23/12 11:29 AM	
	total time	1 hr.	1 hr. 23 min.	1 hr. 10 min.		36 min.	4 hr. 9 min.
	# of chat items	297	388	197		202	1,084

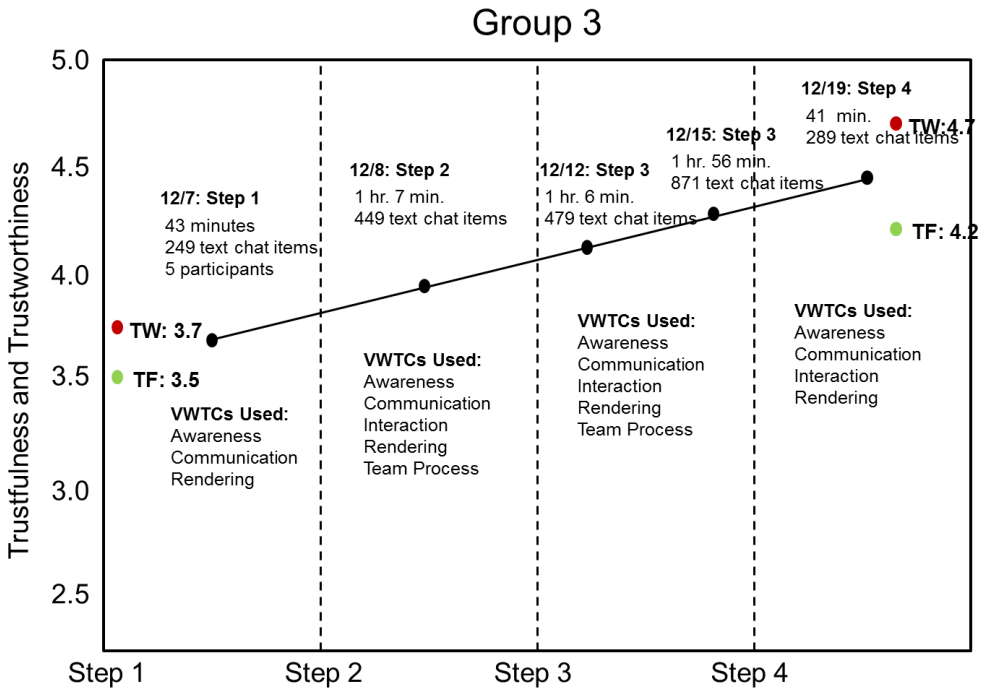
APPENDIX G: GROUP COMMUNICATION BY TASK



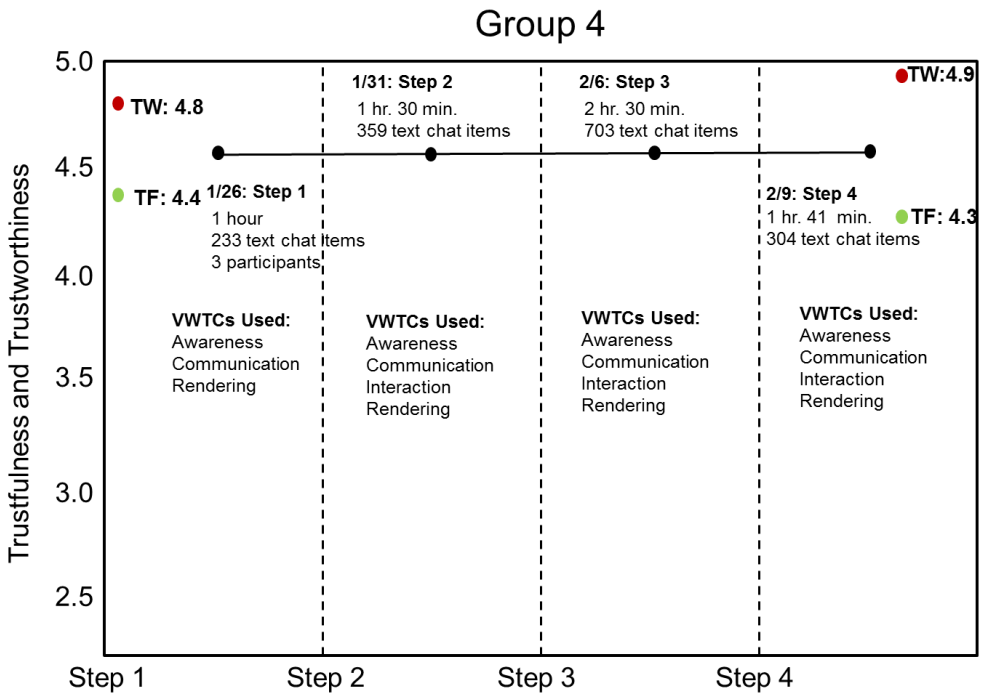
* Each group meeting is represented by a dot ● on the line.



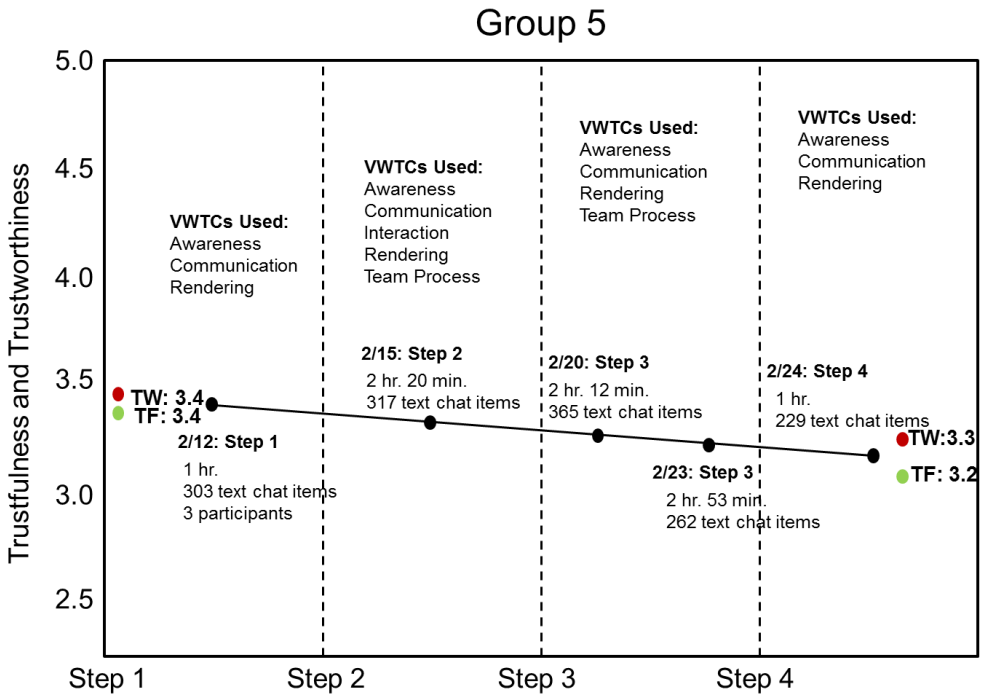
* Each group meeting is represented by a dot ● on the line.



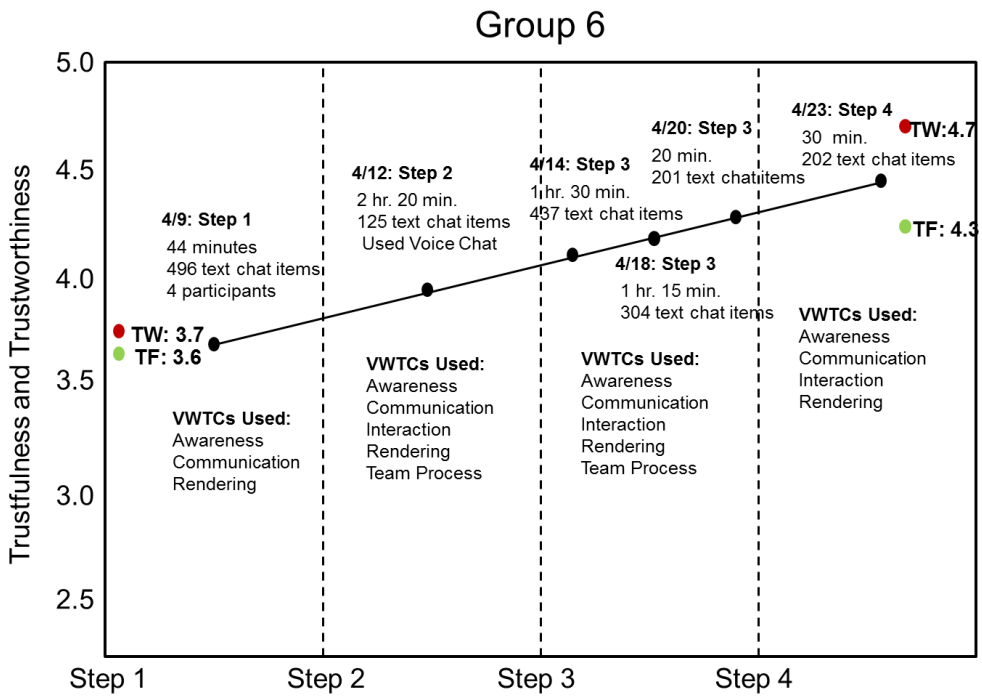
* Each group meeting is represented by a dot ● on the line.



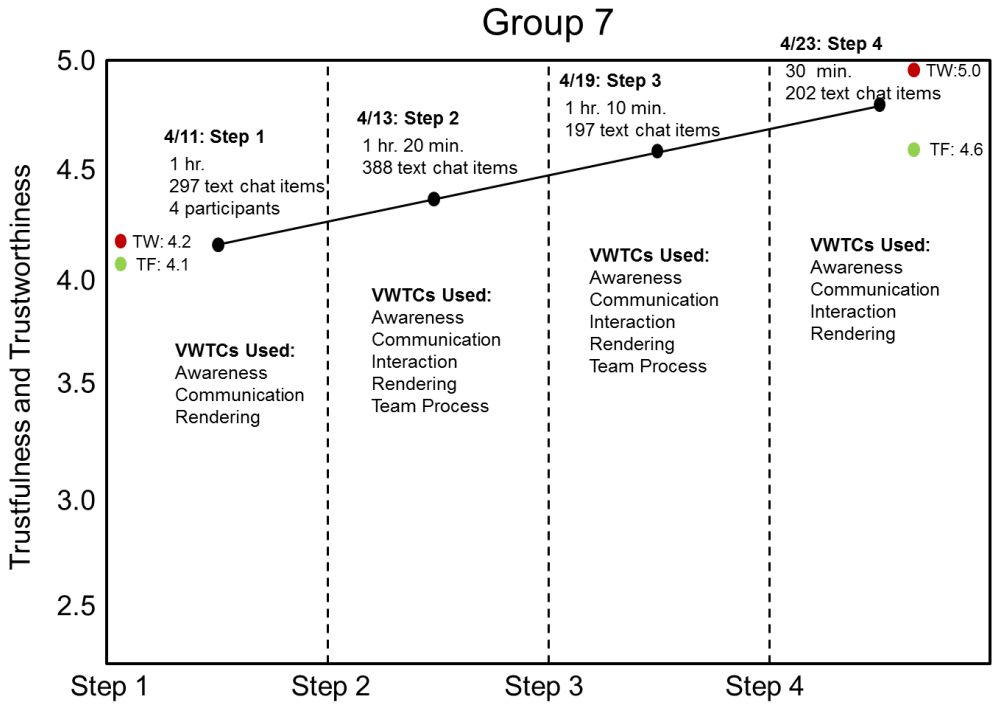
* Each group meeting is represented by a dot ● on the line.



* Each group meeting is represented by a dot ● on the line.



* Each group meeting is represented by a dot ● on the line.

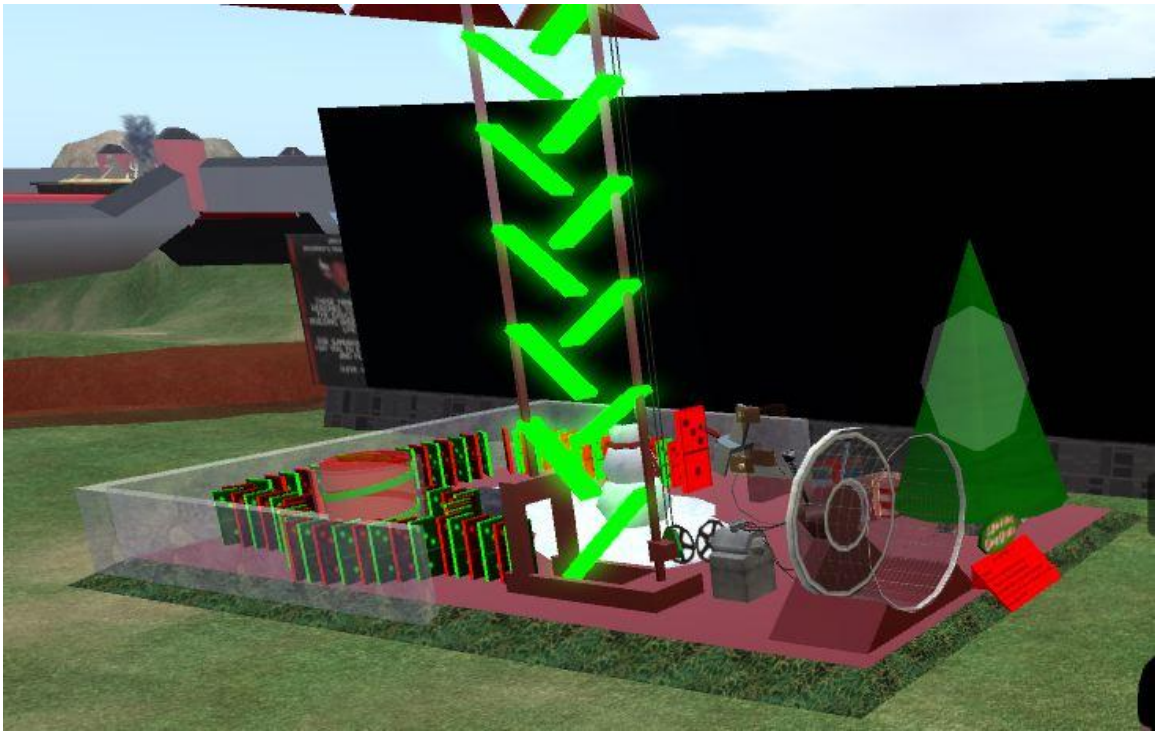


* Each group meeting is represented by a dot ● on the line.

APPENDIX H: FINAL RUBE GOLDBERG MACHINES BY GROUP

Group 1

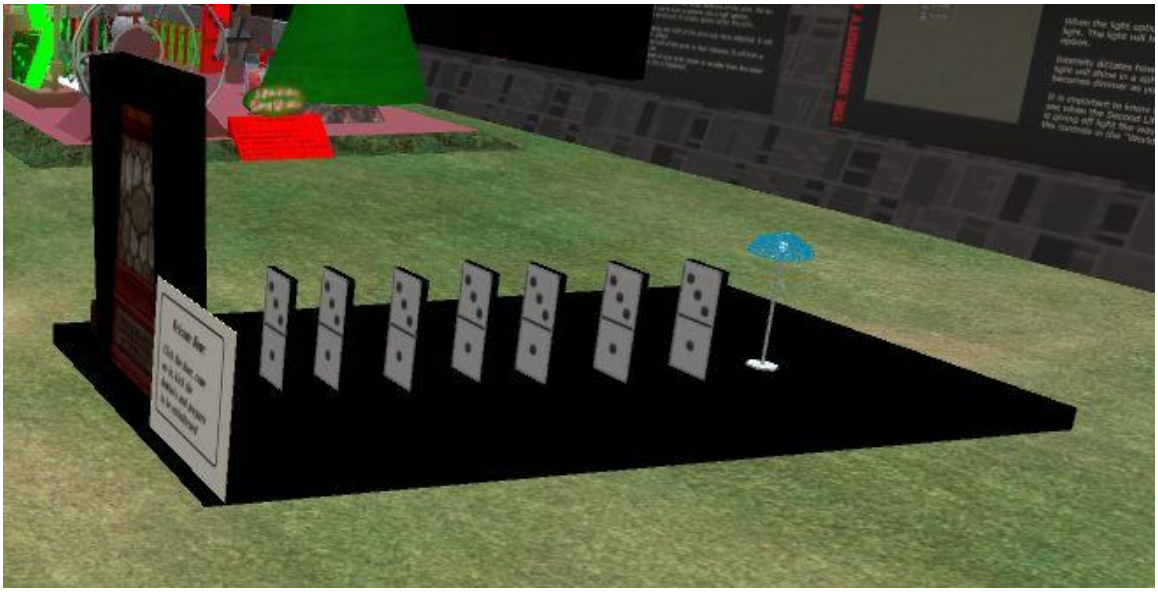
Group 2



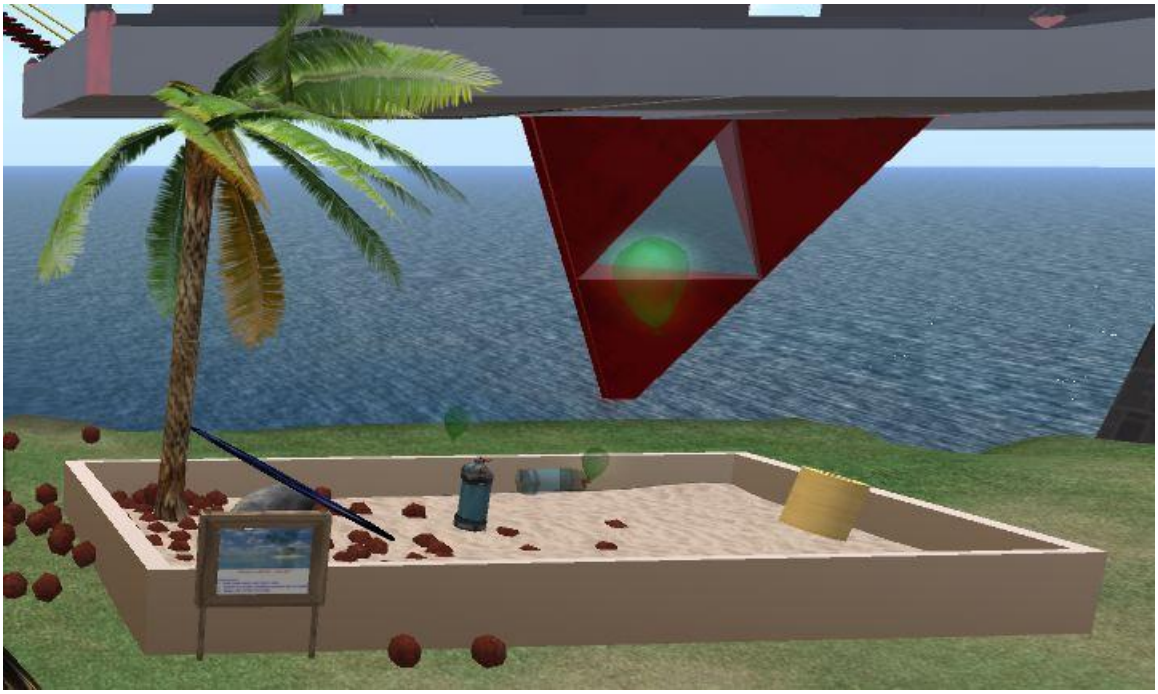
Group 3


The Amazing
RUBE GOLDBERG
INSTANT Breakfast
MACHINE
Click the Cannon
and
Watch the Ball!
Dawn
dmowens

Group 4



Group 5



Group 6

Group 7

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