7-2011

TEAM COLLABORATION IN VIRTUAL WORLDS: THE ROLE OF TASK COMPLEXITY

Parichart Sattayanuwat
University of Nebraska-Lincoln

TEAM COLLABORATION IN VIRTUAL WORLDS:

THE ROLE OF TASK COMPLEXITY

By

Parichart Sattayanuwat

A THESIS

Presented to the Faculty of

The Graduate College of the University of Nebraska

In Partial Fulfillment of Requirements

For the Degree of Master of Arts

Major: Interdepartmental Area of Business

Under the Supervision of Professor Keng Siau and Professor Fiona Fui-Hoon Nah

Lincoln, Nebraska

July, 2011

TEAM COLLABORATION IN VIRTUAL WORLDS:
THE ROLE OF TASK COMPLEXITY

Parichart Sattayanuwat, M.A.

University of Nebraska, 2011

Advisors: Keng Siau and Fiona Fui-Hoon Nah

Virtual worlds are three-dimensional, computer-generated worlds where team collaboration can be facilitated through the use of shared virtual space and mediated using avatars. In this study, we examined the effect of task complexity on team collaboration. We used a puzzle game in Second Life as the collaborative task and manipulated task component complexity by varying the number of pieces in the puzzle. We hypothesized that task complexity would influence team trust, team process satisfaction, and one's attraction to the team in virtual team collaboration. The experimental results indicate that task complexity has significant effects on team trust and team process satisfaction.

ACKNOWLEDGEMENTS

First and foremost, I am heartily thankful to my advisors, Dr. Keng Siau and Dr. Fiona Nah, whose guidance and encouragement enabled me to complete this thesis. They supported me from the beginning until the end of my Marter's program. I am deeply grateful for Dr. Sidney Davis who was willing to serve on my committee at the last moment.

I would like to thank my buddy, David DeWester. He was willing to help me whenever I asked for his assistance. I would also like to thank all my friends who were always cheering me up.

Last but not least, I owe my deepest gratitude to my mom for her love and encouragement. She always supports me in all my pursuits. I gratefully thank everyone in my family for their caring and emotional support. I would never have been able to finish my thesis without them as my motivation.

Table of Contents

Tables

Figures

Chapter 1
Introduction

Virtual worlds can be defined as three-dimensional (3D), computer-simulated environments that replicate elements of the real world. Specifically, virtual environments include a space for interaction – they offer users the ability to interact with and manipulate objects within the space, and the user's "presence" is projected into the space using a graphical representation called an avatar. Through the mediation of the avatar, virtual worlds facilitate real-time social interaction and collaboration by enabling users to cognitively immerse themselves in a shared virtual space, interact and communicate using text and voice, and work together on projects regardless of their physical proximity in the real world. In recent years, virtual worlds have attracted the attention of businesses and researchers as a new and promising technology for collaborative work (Davis, Murphy, Owens, Khazanchi, & Zigurs, 2009).

Virtual collaboration is fast becoming a key theme in organizational applications of virtual worlds (Kock, 2008). Despite the importance and popularity of collaboration and social interaction in virtual worlds, team collaboration in virtual worlds is an underexplored research area. Much of the literature examining computer-mediated teams in the IS domain comes by way of research examining group support systems. Much of this research demonstrates that while technology has a role to play, so too do team characteristics, individual attitudes and behaviors, and the type and nature of the team collaboration task. Many task characteristics have been examined in the literature.

Among them, task complexity has been shown to be one of the most important (Wood, 1986). In this research, we studied the effect of task complexity on team collaboration in a virtual world.

Chapter 2
Literature Review

2.1 Three Dimensional (3D) Virtual Worlds

Three-dimensional (3D) virtual worlds were originally developed from the field of computer games and they evolved from the single player, text-based games of the 1980s to the massively multiplayer online role-playing games (MMORPGs) that are popular today.

Virtual worlds have been developed for multiple purposes; and, there are various forms of virtual worlds (e.g., Second Life, OpenSim, Active Worlds, EverQuest, World of Warcraft, etc.) for social users, gamers, business professionals, educators, and researchers. Despite a wide variety of virtual worlds currently available, they have certain common features. According to Castronova (2001), a virtual world comprises three key features: 1) *interactivity*, 2) *physicality*, and 3) *persistence*.

1) Interactivity

A virtual world can be accessed remotely (i.e. through the Internet) and simultaneously by a large number of people. Inhabiting in a virtual world, people interact with others through their avatars. An avatar is characterized as the three-dimensional digital representation of a user's identity within a virtual environment (Taylor, 2002). Users are in control of their avatars, that is, they are able to transform avatar appearance and manifest avatar behaviors (Yee & Bailenson, 2007).

2) Physicality

People gain access to a virtual world through an interface that creates the illusion of a three-dimensional physical environment somewhat akin to the real world (e.g., gravity, topography, and locomotion). Still, virtual worlds provide possibilities to surpass real-life obstacles (e.g., flying and teleporting). The virtual world environment is filled with virtual objects.

3) Persistence

A virtual world continues to run whether or not anyone is using it; it remembers the location of people and virtual objects, as well as the ownership of objects.

Accordingly, virtual worlds can be defined as persistent, computer-simulated, three-dimensional (3D) environments which mimic elements of the real world, ranging from virtual human beings to virtual objects. People in virtual worlds interact with others as well as with objects in a manner akin to the real world through their graphical representations called avatars.

One of the most prominent 3D virtual worlds is Second Life which is an Internet-based 3D virtual world launched by Linden Lab in 2003. Second Life provides a platform for users or residents to collaboratively create shared content, including objects used by avatars (e.g., clothing, furniture, houses, etc.). In Second Life, residents can 1) explore the environment, 2) socialize with other residents, 3) participate in individual and group activities (e.g., carry out shopping activities, attend conferences or lectures, etc.), and 4) create and trade virtual properties and services with one another (Messinger, et al., 2009). Almost everything in Second Life is created and owned by its residents.

Advances in Internet connections and improvements in 3D virtual-reality technologies have allowed virtual worlds to move far beyond their original vision. The various types of virtual world platforms are now having a major influence on businesses, communities, and society at large (Zhao, Wang, & Zhu, 2010; Messinger, et al., 2009). In addition to the original purposes of virtual worlds, people are forming relationships, conducting businesses, and carrying out collaborative work (i.e., gaming and entertainment) (Hendaoui, Limayem, & Thompson, 2008; Bainbridge, 2007; Castronova, 2001). Messinger et al. (2009) indicated that virtual worlds have a societal impact in two ways: 1) *as the next-generation of the 3D WWW*, and 2) facilitate *rich social interactions*. The latter impact has been considerably appealing to a large number of businesses and researchers who have been exploring ways to effectively leverage the social interaction properties of virtual worlds.

2.2 Virtual Worlds as Collaboration and Communication Platforms

Three-dimensional virtual worlds offer a wide range of possibilities that are not possible with other collaboration technologies such as video conferencing, audio conferencing, and lean channel media (e.g., email and instant messaging). In contrast to video conferencing that offers communication through what is referred negatively as “talking heads”, virtual worlds offer the use of body movements and spatial orientation through avatars (Churchill & Snowdon, 1998). Unlike audio conferencing, 3D virtual worlds also provide non-verbal cues.

Davis et al. (2009) categorize the potential capabilities of virtual worlds into four dimensions: 1) *communication*, 2) *rendering*, 3) *interaction*, and 4) *team process* (see **Table 2.1**).

Table 2.1: Capabilities of Virtual Worlds (Davis et al., 2009)

	Capability	**How capability is, or could be implemented in a virtual world**
Communication	Immediate feedback	- Avatar-to-avatar text or voice chat - Avatar-to-avatar video with communication of facial expressions, body language, and gestures - Synchronous communication
	Multiplicity of cues and channels	- Facial expressions, body language, and gestures of avatar in video - Tone of voice in video or audio chat - Rendering of people through manipulation of clothing and appearance of avatars
	Language variety	- Natural language - Internet language in text chat (e.g., LOL) - Voice manipulation
	Channel expansion	- Training programs offered outside of context - Training offered with tutorials, help toolbar, or FAQs - Avatars must pass training on Orientation Island before joining
	Communication support	- Synchronicity - Anonymity - Feedback - Manipulable objects

**Table 2.1: Capabilities of Virtual Worlds (Continued)
(Davis et al., 2009)**

	Capability	How capability is, or could be implemented in a virtual world
Rendering	Personalization	- Avatar-to-avatar video including eye gazing and other deliberate actions, such as touching - Personalization and rendering of people through clothing and avatar appearance
	Vividness	- Sensory rich mediated environment - Multiple options for presenting information, including three dimensional
Interaction	Interactivity	- Real-time communication - Teleporting
	Mobility	- Teleporting - Flying - Ability to be in different locations
	Immediacy of artifacts	- Immediate creation/building of text, figures, 3D models, images or some combination - Fast modeling or building - Immediate importing of outside files or objects - Software agents and the ability to leave persistent artifacts and avatars behind
Team Process	Process structuring	- The use of a software agent to lead a team and to record meetings
	Information processing	- Three-dimensional brainstorming tools - Three-dimensional organization tools - Three-dimensional voting
	Appropriation support	- Avatar interaction for facilitation or leading - Avatar training use software agents

Undoubtedly, virtual worlds have evolved into sophisticated collaboration and communication platforms and have attracted the attention of both businesses and researchers (Kahai, Carroll, & Jestice, 2007; Davis et al., 2009; Kock, 2008). Siau, Nah, Mennecke and Schiller (2010) advocate that virtual worlds are a new promising information technology (ICT) that can facilitate collaborative work and learning. In light of increasing competition and globalization as well as the need to save time and minimize travel expenses, many organizations are relying more heavily on virtual teams (Kock, 2000). Virtual teams are geographically dispersed and they work interdependently in order to accomplish a common goal through the use of collaboration technologies (e.g., audio conferencing, video conferencing, and computer-mediated systems) (Dubé & Paré, 2004; Lipnack & Stamps, 1997; Wainfan & Davis, 2004). Many collaboration technologies fail to provide an experience equivalent to face-to-face communication (e.g., lack of media richness, lack of non-verbal cues, and lack of social context). In contrast, 3D virtual worlds can support a greater level of interactivity and richness for collaboration and communication.

A virtual world creates an illusion of a shared virtual workspace in which virtual team members can simultaneously interact, collaborate, and cooperate with one another to achieve a common goal using their avatars as the nexus of communication (Mennecke, Triplett, Hassall, Conde, & Heer, 2011). With their avatar-mediated technology, virtual worlds have the potential to facilitate real-time social interactions among users through their avatars. This embodied representation enables richer forms of interaction compared to traditional media (Mennecke et al., 2011; Gerhard, Moore, & Hobbs, 2004).

Not only do 3D virtual worlds enable virtual teams to communicate synchronously via chat or audio channels, but they also allow virtual teams to carry out activities simultaneously using various types of shared applications (e.g., presentation or spreadsheet programs). In addition, 3D virtual worlds allow users to create, move, and manipulate in-world objects. Indeed, team members can cooperatively manipulate objects in a shared virtual space (Schroeder, Heldal, & Tromp, 2006; Slater, Sadagic, Usoh, & Schroeder, 2000), which facilitates team members' engagement in cooperative tasks and activities (Siau et al., 2010).

Researchers from social sciences, psychology and information systems have been exploring the potential of virtual worlds as a technological platform for virtual team collaboration, and studying team collaboration in terms of team behaviors, team process and outcomes, and communication capabilities (Kock, 2008; Davis et al., 2009; Kahai et al., 2007). Recent studies have used virtual worlds as research environments for the study of virtual team phenomena (e.g., Picot et al., 2009; Korsgaard, Picot, Wigand, Welpe, & Assmann, 2010). These researchers claimed that virtual worlds tend to be highly engaging and psychologically meaningful to subjects.

3D virtual worlds may provide an environment for team building that enhances team identification in virtual teams (Ellis, Luther, Bessiere, & Kellogg, 2008). Because virtual teams typically lack socio-emotional communication, resulting in lower trust and cohesion, Ellis et al. (2008) suggested that Second Life, one of the most prominent virtual worlds, can be used as the environment for designing cooperative games for virtual teams.

Apparently, 3D virtual worlds broaden the range of opportunities for employing virtual team collaboration, offering environments in which rich interaction (Schroeder et al., 2006) and engaging collaboration (Davis et al., 2009; Kahai et al., 2007) among users are facilitated. Not surprisingly, 3D virtual worlds have increasingly played a crucial role in supporting virtual collaboration and fostering team effectiveness (Korsgaard et al., 2010).

2.3 Trust

Working together deals with interdependence; that is, team members depend upon others to achieve common tasks. As a result, mutual trust is indispensable for enabling team members to work together effectively (McAllister, 1995). Prior research on trust has emphasized that trust is a complex, multidimensional construct. In particular, there are two board dimensions of trust: 1) *cognitive-based trust*, and 2) *affective-based trust* (McAllister, 1995).

Cognitive-based trust refers to the calculative and rational characteristics demonstrated by trustees. Examples of the trustees' characteristics include reliability (McAllister, 1995), integrity, competence (Mayer, Davis, & Schoorman, 1995), and responsibility (Cook & Wall, 1980). On the other hand, affective-based trust involves the emotional elements and social relationships associated with perceptions of the other actor, their history working together, and similar affective characteristics associated with their interactions. Care and concern for others' welfare form the basis for affective-based trust (McAllister, 1995).

The relative importance of these two dimensions varies due to the context and the type of relationship among people (Lewis & Weigert, 1985). Cognitive-based trust has been studied mainly in the context of working groups (Meyerson, Weick, & Kramer, 1996). In contrast, affective-based trust has been studied in the context of close social relationships such as couples, family members, and friends (Boon & Holmes, 1991). Many researchers have argued that trust in virtual team settings is best described by the cognitive dimension than the affective dimension (Meyerson et al., 1996; Peters & Manz, 2007; Robert, Dennis, & Hung, 2009; Jarvenpaa & Leidner, 1999; Jarvenpaa, Knoll, & Leidner, 1998). In addition, Kanawattanachai and Yoo (2002), who examined Meyerson et al.'s propositions, showed that virtual teams relied more on cognitive-based trust than affective-based trust. Thus, cognitive-based trust should be more salient and influential in virtual team collaboration examined in this current study.

Mayer et al. (1995) argued that trust is an important aspect of relationships, and trust varies within persons and across relationships. According to their "integrative" model of trust, trust is affected by a trusting party (i.e., trustor) and a party to be trusted (i.e., trustee). Mayer et al. (1995) defined trust as "*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). Making oneself vulnerable is taking risk; therefore, trust is a willingness to take risk. The basis of the model was to understand how parties process information about others, thereby deciding how much risk to take with others. As such, the model represents a *cognitive* approach to trust.

Propensity to trust is referred to as a trait of the trustor which influences the extent to which the trustor will trust others prior to availability of information about a particular trustee (Mayer et al., 1995). Some individuals are more likely to trust than others. Factors resulting in variation in propensity to trust include developmental experiences, personalities, and cultural background.

Trustee characteristics perceived by the trustor are viewed as antecedents of trust; that is, they determine trustworthiness. Three characteristics of the trustee that are relevant are: 1) *ability*, 2) *benevolence*, and 3) *integrity* (Mayer et al., 1995). Ability refers to the trustee's skills, competencies, and knowledge within some specific domain. Benevolence is the extent to which the trustee is believed to want to do good to the trustor. Integrity refers to the trustor's perception that the trustee adheres to a set of principles that is acceptable to the trustor.

The concept of trust has been studied extensively in virtual teams (Mitchell & Zigurs, 2009). In the virtual team literature, trust is one of the vital behaviors (Dubé & Paré, 2004; Zigurs, 2003) and challenging issues (Khazanchi & Zigurs, 2006; Pinsonneault & Caya, 2005) for virtual teams. Trust functions like the glue of virtual teams which, in turn, determines the success and failure of a virtual team (Lipnack & Stamps, 1997). It is essential that virtual team members establish trust in order to achieve the same goal (Jarvenpaa & Leidner, 1999; Peters & Manz, 2007). Trust among virtual team members plays a crucial role in team performance. When mutual trust is present among team members, it typically produces higher quality outcomes (Sarker, Valacich, & Sarker, 2000).

Virtual teams normally are formed in order to work on a short-lived project; as a result, they might not have sufficient time to gather information about others in their teams. It is difficult for team members to establish trust in a new working relationship. To successfully accomplish a collaborative task, team members need to trust the other members. They base their judgments of the trustworthiness of their team members not on past experiences, but rather on common group membership (Meyerson et al., 1996). According to Meyerson et al. (1996), "*people have to wade in on trust rather than wait while experience gradually shows who can be trusted and with what: Trust must be conferred presumptively or ex ante*" (p. 170). Meyerson and his colleagues (1996) defined such trust as *swift trust*. Swift trust provides an explanation of the finding that some teams manage to establish high levels of trust that enable them to function in high risk, high vulnerability situations.

In Jarvenpaa and Leidner's (1999) study, the findings suggest that trust could be swiftly established in virtual teams in which team members collaborated via electronic communication. Fifteen out of twenty-nine teams showed high levels of trust from the outset of the project. Furthermore, the study indicated that teams that started and ended with high levels of trust achieved an outstanding performance. Jarvenpaa and Leidner (1999) also cautioned that swift trust is short-lived and fragile. In a virtual team setting, even if teams are able to initially develop high trust, it is possible that such swift trust can be easily destroyed later.

2.4 Attraction to Team/Group

Attraction to team is one of the most widely studied characteristics of team processes (Kozlowski & Ilgen, 2006). While some researchers have equated attraction to team with team cohesion, Van Bergen and Koekebakker (1959) argued that attraction to team and team cohesion should be considered separate constructs. They claimed that attraction to team is "*on a lower level of abstraction than cohesiveness*" (p. 82). Accordingly, attraction to team may be more easily operationalized and measured (Casey-Campbell & Martens, 2009).

Moreover, Evans and Jarvis (1980) asserted that although attraction to team is a concept related to team cohesion, it is distinct from cohesion. Gross and Martin (1952) categorized attraction to team as interpersonal cohesion. Kozlowski and Ilgen (2006) maintained that this dimension of cohesion allows teams to have less inhibited communication and to effectively coordinate their efforts. Evans and Jarvis (1980) defined mutual attraction of members to the collective as the most common definition of cohesiveness. According to Evans and Jarvis (1980), *attraction to team* refers to an individual's desire to identify with and be an accepted member of the team.

Members who find their teams attractive are more likely to remain members of the team, and who are more willing to contribute to team discussion and self-exploration (Sagi, Olmstead, & Atelsek, 1955). An individual with a high need for belonging or a high need for affiliation may have strong motivations to remain with a team (Casey-Campbell & Martens, 2009). The level of a team member's attraction to his/her team contributes to the development of the team and team outcomes (Evans & Jarvis, 1986).

Research has generally reported a positive relationship between attraction to team and performance (e.g., Smith et al., 1994; Dorfman & Stephen, 1984; Mullen & Copper, 1994). Beal and his colleagues (2003) clarified the relationship between attraction to team and team performance. They differentiated performance as behavior (i.e., what team members do) from performance as outcomes. The meta-analyses conducted by Beal et al. (2003) showed that attraction to team was more strongly related to performance behaviors than to outcomes.

Gully, Devine, and Whitney (1995) examined task interdependence as a moderator. When team members have to coordinate their effort, skill, and knowledge in complex and highly interdependent tasks, attraction to team is more strongly related to team performance than in simple tasks.

In addition, Shaw (1981) explained that the expected positive relationship between attraction to team and performance was attributed to the notion that team members would work harder to attain group goals, when attraction to team was high. Attraction to team may lead to improvement in communications between team members, which, in turn, enhances participation as well as goal, task, and role acceptance (Cartwright, 1968). As a result, a number of organizations have developed training programs which offer team experiences that will promote team cohesiveness and team members' attraction to the group (Casey-Campbell & Martens, 2009).

2.5 Team Process Satisfaction

Team process satisfaction refers to the affective and positive emotional reaction team members have with the ways (e.g., procedure, deliberation, etc.) they arrive at an outcome (Lowry, Romano, Jenkins, & Guthrie, 2009; Reining, 2003). Lowry et al. (2009)

argued that the goal setting theory is useful for understanding and explaining team process satisfaction.

According to the goal setting theory, goals are defined as something that a person wants to achieve or his/her desired end states (Locke & Latham, 1990a; 1990b). Satisfaction (i.e., affect) is affected when individuals perceive that an object facilitates or hinders the attainment of value (Locke & Latham, 1990a). The strength of the affect is associated with the intensity of the value attributed to the object and the degree to which the value is perceived to have been attained. An object refers to what can be perceived such as actions, ideas, persons, situations, or prior emotions (Locke & Latham, 1990a).

According to Locke and Latham (1990a), individuals can be motivated by goals on the basis of the extent to which a particular goal has task complexity, challenge, commitment, clarity, and feedback. Individuals who have more difficult but attainable goals perform better than those who have less difficult goals (Locke & Latham, 1990b).

Further, some studies shed light on the impact of task interdependence on satisfaction with the group. Task interdependence indicates the degree to which group members interact and rely on each other to accomplish work and is related to satisfaction (Campion, Papper, & Medsker, 1996; Campion, Medsker, & Higgs, 1993). Shaw, Duffy and Stark's (2000) empirical study has shown that individual's satisfaction with the group is positively associated with task interdependence, reward interdependence, and preference for group work. Shaw et al. (2000) explained that increased satisfaction in high task interdependence resulted from the notion that working on tasks closely with others might be more enjoyable and satisfying experience than working alone.

Many research studies in computer-mediated communication (CMC) or group support systems (GSS) include team process satisfaction as a team performance measure (Carey & Kacmer, 1997). Satisfaction is an important determinant of group collaboration success, and plays a crucial role in establishing commitment to team decisions (Lowry et al., 2009). In both face-to-face and virtual teams, lack of satisfaction can lead to dysfunctional teams (Lurey & Raisinghani, 2001; Lowry et al., 2009).

Chapter 3
Theoretical Foundation

The nature of a group's task plays an important role in a group's interaction process (Poole, Siebold, & McPhee, 1985). Poole et al. (1985) pointed out that "*the general variable 'group task type' is emerging as an especially important variable, often accounting for as much as 50% of the variance in group performance*" (p. 88). The task assigned to a group has been shown to influence group behavior and effectiveness (Mennecke & Wheeler, 1993; Hackman & Morris, 1975). Our main purpose of this study is to assess the effect of task complexity on team trust, attraction to team, and team process satisfaction. Since task complexity is an important characteristic of group tasks, understanding group tasks is also essential.

A group task can be categorized by its goals, rules and roles that must be followed, criteria for completion, stress imposed on the team members, or consequences of failure or success (Hare, 1962). Accordingly, a number of task categorization schemes have been proposed in the group literature in an attempt to examine the role of group tasks and their effects on team processes and outcomes. In this study, a literature review on group tasks will be presented to understand and define the role of tasks. This study employs Hackman's (1969b) task framework to examine how tasks influence individuals' behavior and attitudes. We classified our experimental task (i.e., puzzles) based on McGrath's (1984) task circumplex, which is one of the most widely used and cited classification schemes.

Furthermore, the concept of task complexity will be reviewed. Task complexity is one of the task dimensions, serving as a determining variable in describing task performance through the demands it places on the knowledge, skills, and efforts of the individual task performer (Wood, 1986; Campbell, 1988).

3.1 Group Tasks

3.1.1 Hackman's Framework for Analyzing the Effects of Tasks

Hackman (1969b) proposed a framework for gaining insight into how tasks and task factors influence behavior. He evaluated four theoretical approaches, originally proposed by Ferguson (1956) as well as McGrath and Altman (1966), for differentiating and classifying tasks.

1) Task qua task

Tasks are defined as a pattern of stimuli that affects the individuals. Task qua task characteristics refer primarily to the physical nature of the stimuli (e.g., stimulus input rate) or the actual task materials (e.g., clarity of instructions). Thus, task qua task characteristics relate to objective properties of tasks for which a researcher can specify a single, definite value by suitable measurement and control (Roby & Lanzetta, 1958).

2) Task as behavior requirement

Tasks are defined in terms of the behavioral responses a person should emit to achieve some performance criterion. Characteristics of this approach include task demands (i.e., the amount of resources required to obtain maximum productivity (Steiner, 1966)) and the type of interactions required to achieve the task (Altman, 1966).

3) Task as behavior description

Tasks are described in terms of the actual behaviors that people exhibit, given the stimulus conditions. This approach describes tasks in terms of the typical behavior of individuals who perform the task.

4) Task as ability requirement

Tasks are described by the patterns of personal abilities or traits, which are required to perform the tasks. This approach attempts to differentiate tasks by identifying the skills and abilities to complete the task.

Hackman (1969b) asserted that both "*task as behavior description*" and "*task as ability requirement*" approaches are unsuitable because they rely heavily upon characteristics of task performers that vary across individuals for a given task.

Although the "*task qua task*" approach can separate effects due to task characteristics from the individual effects, Formulating the operational definition of objective task characteristics is a very difficult problem. The number of potential stimuli confronting an individual in any given situation is almost infinite. The "*task qua task*" approach leaves the researcher with the difficult problem of operationalizing objective task characteristics (Hackman, 1969b). The "*task as behavior requirement*" approach refers to the nature of behaviors which a person should emit to perform a task. Behavior requirements differ from task to task. Additionally, the set of behaviors required for task completion will remain constant across the task performer for any given task. Behavior requirements can be viewed as characteristics of tasks rather than characteristics of the performer. As a result, Hackman (1969b) suggested that the "*task as behavior requirement*" approach provides a basis for understanding the differences among tasks and their effects on behavior. Hackman (1969b) also termed behavior requirements as *process-outcome links* (later discussed in Hackman's task framework) because the behavior requirements mediate between what a performer does (i.e., behavioral process in working on the task) and the outcomes resulting from the performer's behavior.

Hackman's (1969b) definition of task is as follows: *"A task may be assigned to a person (or group) by an external agent or may be self-generated. It consists of a stimulus complex and a set of instructions which specify what is to be done vis a vis the stimuli. The instructions indicate what operations are to be performed by the subject(s) with respect to the stimuli and/or what goal is to be achieved."* (p. 113).

Based on Hackman's (1969b) definition, a task comprises three important components: 1) *stimulus materials* (e.g., complexity, familiarity, task load, etc.), 2) *instructions about operations* (e.g., cooperation requirements, decision-making tasks, etc.), and/or 3) *instructions about goals* (e.g., criteria for task completion, goal clarity, solution multiplicity, etc.).

In order to understand the effects of tasks on a performer's behavior, Hackman (1969b) proposed a task framework (see **Figure 3.1**). Characteristics of the performer which are likely to influence task performance are presented at the bottom of the figure.

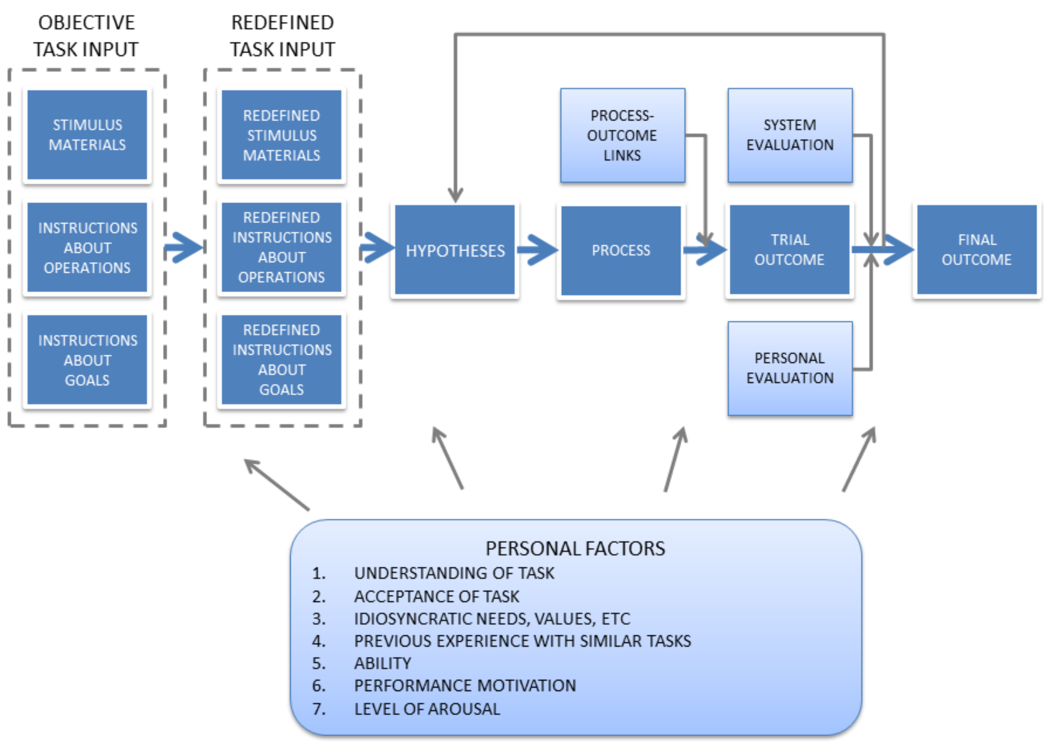


Figure 3.1: Hackman's Task Framework (Hackman, 1969b, p. 118)

However, the objective task is not the one actually dealt with by any given performer, because of the process of task redefinition. A performer's own understanding of a task is usually different from the objective task. Hackman (1969b, p. 119) highlighted *"Since the information included in the objective statement of the task must be perceived and coded by the subject before it becomes useful to him, all of the factors which affect the dynamics of perception (e.g., needs, values, etc.) potentially will contribute to task redefinition."* The task redefinition process can be viewed as the sequence of behaviors which occur between when a performer receives the task and when he starts actual work on it. There are four factors which seem most likely to affect the nature of the performer's redefinition of the objective task: a) the degree to which the task performer *understands* the task, b) the degree to which the task performer *accepts* the task and is willing to cooperate with its demands, c) the *idiosyncratic needs and values* which the task performer brings to the task scenario, and d) the impact of *previous experiences* with similar tasks.

The framework further points out that, after the performer has cognitively redefined the task, he formulates hypotheses about how he is supposed to deal with the task, such as hypotheses about the strategy of performance and hypotheses about the actual behaviors which will be performed. The specific hypotheses which are formed will depend upon the characteristics of the performer and upon the redefined task. For instance, previous experience with similar tasks is important in determining the nature of the hypotheses a task performer develops.

The next stage in the task performance process is labeled as "*process*" and refers to a performer's actual task-based behaviors. Like the other stages, process is moderated by personal factors, for example, the performer's task-relevant abilities and his motivation to perform. It should be noted that the performer's motivation is not merely the motivation he brings to the performance situation. The characteristics of the task itself (especially stimulus materials) can affect the performer's level of motivation, subsequently affecting the level or direction of performance.

Some outcomes results from the actual task process. These are called "trial outcomes" since they may be evaluated by the performer. If evaluation is unfavorable, the performer will try something else to see if he can improve upon his trial outcome. In contrast, if evaluation is favorable, the trial outcome becomes the final outcome, and the task performance process terminates. There are two general types of outcomes (Hackman, 1969b): 1) *personal outcomes* which are the performer's reactions to the task experience (e.g., attitude change, satisfaction, frustration, etc.), and 2) *objective outcomes* which are the products of the task performance process (e.g., a written passage, an assembled device, etc.).

As shown in **Figure 3.1**, the process-outcome links refer to the means by which particular responses are translated into particular outcomes. As mentioned earlier, the process-outcome links denote behavior requirements; thus, these links are those characteristics of the task or the situation which define what outcomes result from various behaviors on the part of the performer.

In summary, drawing on the task framework, Hackman (1969a) suggested that there are four different ways in which tasks can influence behavior. First, tasks can affect a performer's behavior through the hypotheses he formulates about what he should do in response to a task. Second, cues that are inherent in tasks and situations can influence or arouse certain motive states of performers (e.g., achievement, affiliation, power, sex, etc.). Individuals frequently behave differently when they are dealing with tasks which arouse different motive states. Third, tasks have impacts on the performers' levels of cognitive and physiological arousal or activation (e.g., complexity, uniqueness, or variety associated with the task). Performance will be indirectly affected by the changed level of arousal. Lastly, task effects may operate through the process-outcome links which determine what behaviors result in what outcomes. **Figure 3.2** illustrates these four types of task impact on the performance process.

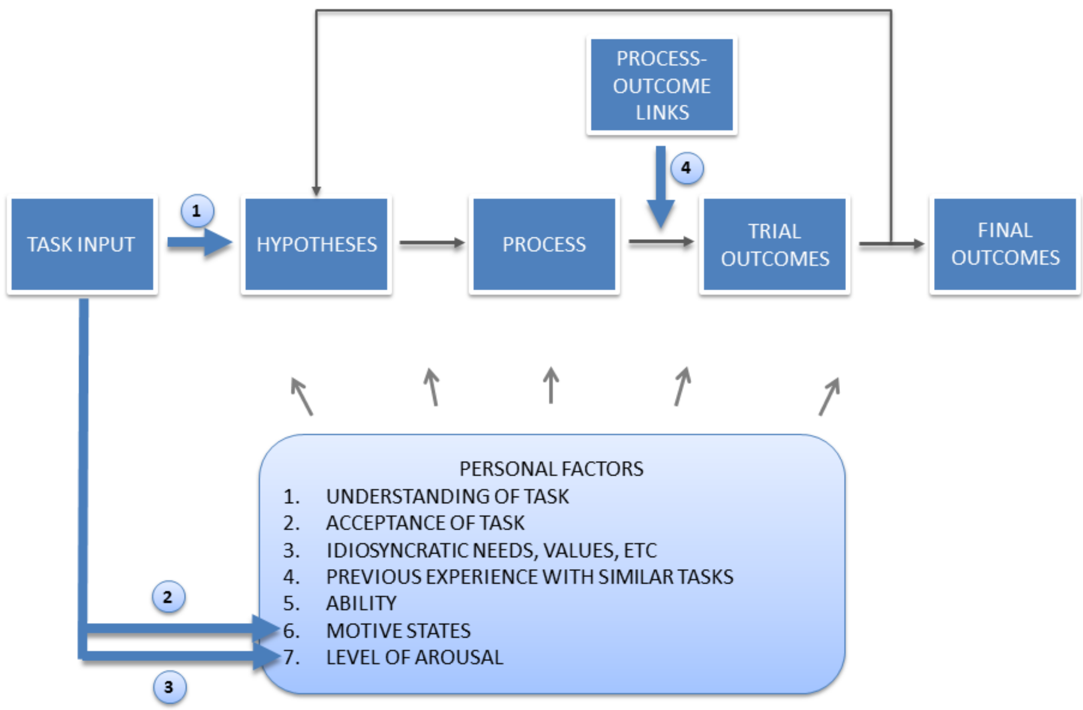


Figure 3.2: Four Types of Impacts of Tasks (Hackman, 1969a)

3.1.2 McGrath's Task Circumplex

McGrath's (1984) task circumplex is one of the most widely cited classification schemes in group research. The task circumplex classifies group tasks into categories that are mutually exclusive, collectively exhaustive, and logically related to one another (McGrath, 1984). The task circumplex is a two-dimensional representation: 1) the *horizontal dimension* refers to whether the task entails cognitive or behavioral performance requirements, and 2) the *vertical dimension* refers to the degree to which the task involves cooperation or conflict.

McGrath distinguished four task categories with regard to performance processes: 1) *generate* (plans or ideas), 2) *choose* (a correct answer or a preferred solution), 3) *negotiate* (conflicting viewpoint or conflicting motive interest), and 4) *execute* (in competition with an opponent or in competition against external performance standards) (see **Figure 3.3**).

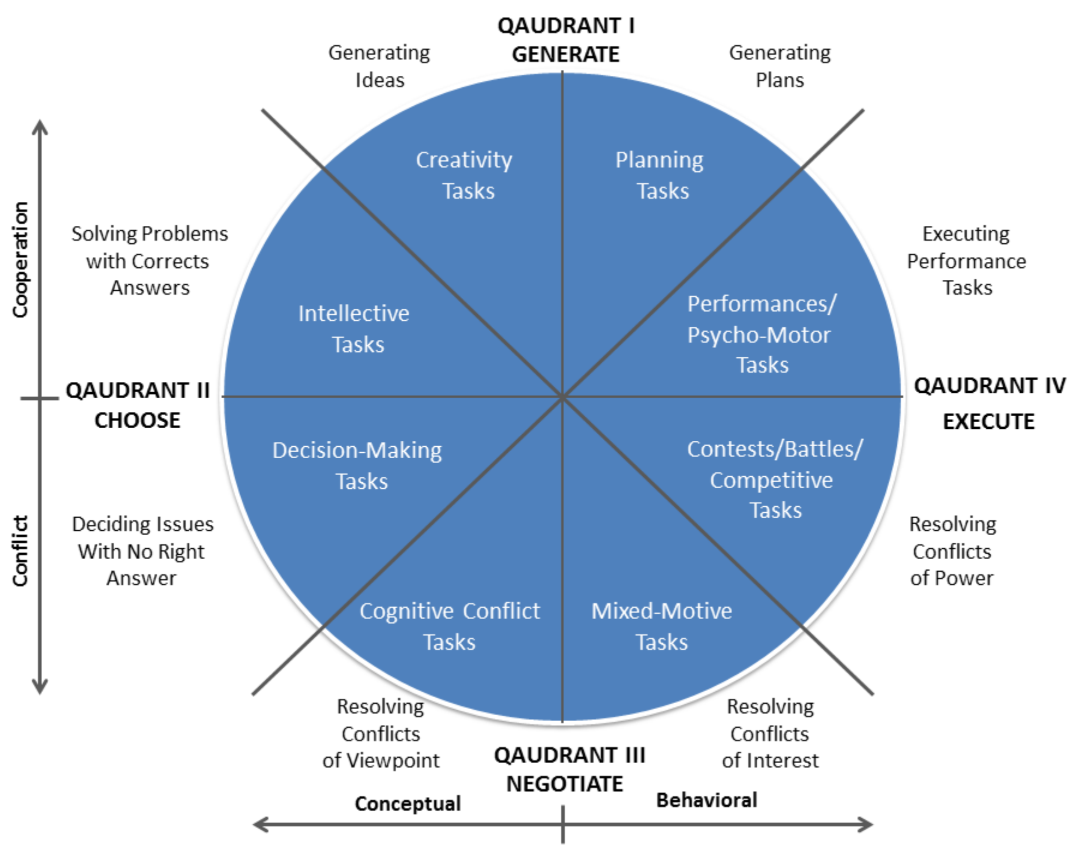


Figure 3.3: McGrath's Task Circumplex

3.2 Task Complexity

3.2.1 Wood's Model of Task Complexity

Wood (1986) proposed a theoretical framework for task complexity. In order to explain task effects independently of individuals who perform the task, Wood's (1986) task complexity framework has drawn on "*task qua task*" and "*tasks as behavior requirement*" frameworks discussed by Hackman (1969b). Wood (1986) employed the "*task as behavior requirement*" framework for tasks which involve physical and motor activities. In addition to drawing upon the "*task as behavior requirement*" framework, Wood's (1986) task complexity framework was also built upon the "*task qua task*" framework for tasks involving judgment and inference. Accordingly, adopting a combination of those two frameworks, Wood (1986) posited that the components of a task are threefold: 1) *products*, 2) *required acts*, and 3) *information cues*.

Products refer to entities produced through task-related acts or behaviors that are independent of the goals and expectations of individual task performers. A task product must be determined before task inputs (i.e., required acts and information cues) can be specified. A product is a set of identifiable attributes which can differentiate tasks and behavioral requirements.

Required acts refer to a pattern of behaviors with some identifiable purpose, which are treated as the basic unit of behavioral requirements. Wood (1986, p. 65) also highlighted that required acts represent merely task components needed for task completion, not properties of an individual task performer.

Information cues refer to pieces of information about the attributes of task stimuli. Task performers process these information cues to make judgments while they are performing the task.

Specifically, required acts and information cues are considered as *task inputs* that determine the demands placed on the knowledge, skills, and effort that individuals require for task performance (Wood, 1986, p. 66). Due to the fact that task inputs (i.e., acts and information cues) and products can differentiate one task from another, Wood (1986) suggested that the construct of task complexity serves as a determining factor of task performance through the demands for the knowledge, skills, and effort of individual task performers. As a result, Wood (1986) derives three types of task complexity: 1) *component complexity*, 2) *coordinative complexity*, and 3) *dynamic complexity*.

Component complexity is a direct function of the number of distinct acts that are required to complete a task and the number of distinct information cues that are processed to execute those acts. Wood (1986) also noted that a task may involve the completion of several other tasks, which results in task products as inputs or subtasks of the larger task. Component complexity, thus, may require measures at the subtask level in addition to the act and information cue levels. Increases in each of these components (i.e., acts, information cues, and subtasks) result in increases in the knowledge and skill requirements for task completion. Thus, the larger the number of each of these components (i.e., acts, information cues, and subtasks), the greater the component complexity (Wood, 1986).

Coordinative complexity refers to the form and strength of the relationships between acts, products, and information cues, as well as the sequencing of inputs. Timing, frequency, intensity, and location requirements for performing required acts are also included in coordinative complexity. The more complex the timing, frequency, intensity, and location requirements, the greater the knowledge and skill an individual requires to be able to perform the task, and hence, the greater the coordinative complexity (Wood, 1986).

Dynamic complexity is a function of factors that are related to stability of the relationships between task inputs and products. For example, tasks which are performed over longer periods of time or tasks which are relatively unique generate a higher level of dynamic complexity. Shifts in the knowledge or skills required for a task are caused by changes in either the set of required acts and information cues or the relationships between task inputs and products (Wood, 1986).

3.2.2 Campbell's Typology of Task Complexity

Campbell (1988) reviewed approaches to task complexity and found that task complexity in the literature has been treated as:

1) Complexity as primarily psychological

Task complexity is treated as a subjective, psychological experience of the task performer (e.g., the differential feelings of autonomy, variety, feedback, and identity). This approach exclusively focuses on the subjective reactions of the individual to the task rather than on specific task characteristics (Campbell, 1988, p. 41).

2) Complexity as a person-task interaction

This approach pays significant attention to both the task performer and the task when identifying complexity. For example, task complexity is defined in terms of the capabilities of the individual who performs the task. A task is more or less complex relative to the abilities of the individual performing the task. In general, this approach implies that task complexity cannot be examined independently of considerations of short-term memory, span of attention, computational efficiency, and so forth, as they are affected by task representation (Campbell, 1988, p. 42).

3) Complexity as objective task characteristics

Task complexity is defined in terms of the objective dimensions of task characteristics. Hence, complexity is derived from such task qualities as uncertain alternatives, path-goal multiplicity, conflicting elements, the amount of information involved in a task, and so forth (Campbell, 1988, p. 42).

Campbell (1988) proposed an integrative framework based on objective task characteristics. Like Wood's (1986) framework, Campbell's (1988) proposed framework of task complexity is aimed at determining complexity independently of any task performer. Campbell (1988) utilized three important dimensions of information processing outlined by Schroder, Driver, and Streufert (1967) as a useful means of defining task complexity objectively and translating the implications of the task characteristics into person processes.

The three constructs of information processing consist of 1) *information load* (i.e., the number of dimensions of information requiring attention), 2) *information diversity* (i.e., the number of alternatives associated with each dimension), and 3) *the rate of information change* (i.e., the degree of uncertainty involved). Task complexity is directly associated with these three constructs of information processing; that is, an increase in each construct results in an increase in task complexity. Moreover, the three dimensions of information processing can capture the cognitive demands experienced by a task performer in completing a task (Schroder et al., 1967). Hence, a complex task places high cognitive demands on the task performer (Campbell & Gingrich, 1986).

Any task characteristic that leads to an increase in information load, information diversity, or rate of change will increase task complexity. In Campbell's (1988) proposed framework, four objective task characteristics, which give rise to a high level of information load, information diversity, or rate of information change, are composed of 1) *the presence of multiple paths*, 2) *the presence of multiple outcomes*, 3) *the presence of conflicting interdependence* among paths to outcomes, and 4) *the presence of uncertain or probabilistic links* among paths and outcomes (See **Table 3.1**).

Table 3.1: Task Characteristics (Campbell, 1988)

Task Characteristics	Complexity	
	Increase	**Decrease**
***Multiple paths*:** Multiple potential ways to arrive at a desired outcome.	An increase in the number of possible ways to arrive at a desired outcome	All paths are likely to result in the desired outcome (redundancy).
***Multiple outcomes*:** Multiple desired outcomes to be attained.	An increase in the number of desired outcomes	The desired outcomes are positively related. (redundancy)
***Conflicting interdependence among paths*:** Achieving one desired outcome conflicts with achieving another desired outcome.	Negative relationships among desired outcomes	
***Uncertain or probabilistic linkages*:** The connection between potential path activities and desired outcomes cannot be established with certainty.	An increase in uncertainty through enlarging the pool of potential paths to a desired outcome.	

Campbell (1988) developed a typology of complex tasks by using task characteristics (i.e., multiple paths, multiple outcomes, conflicting independence among paths, and uncertain or probabilistic linkages) discussed earlier. A classification of task types is determined both by the degree to which a task incorporates each particular characteristic (e.g., presence or absent; high or low) and by the total number of the characteristics contained in the task (Campbell, 1988, p. 46). **Table 3.2** represents a typology of complex tasks proposed by Campbell (1988).

Table 3.2: Typology of Complex Tasks (Campbell, 1988)

Task Classification	Multiple Paths	Multiple Desired Outcomes	Conflicting Interdependence	Uncertainty or Probabilistic Linkage	Examples
Simple Tasks	-	-	-	-	
Decision Tasks	-	X	-	-	Employee selection; Choosing a house; Selecting a building site.
	-	X	-	X	
	-	X	X	-	
	-	X	X	X	
Judgment Tasks	-	-	X	-	Intelligence analysis; Stock market analysis; Multiple cue probability learning.
	-	-	-	X	
	-	-	X	X	
Problem Tasks	X	-	-	-	Chess problems; Personnel scheduling; Personnel placement.
	X	-	X	-	
	X	-	-	X	
	X	-	X	X	
Fuzzy Tasks	X	X	-	-	Business ventures.
	X	X	-	X	
	X	X	X	-	
	X	X	X	X	

Chapter 4
Hypothesis Development

4.1 Research Framework

This study was aimed to examine the effect of task complexity on group behavior. According to Wood (1986), variations in task complexity (e.g., different types and different levels of complexity) appear to result in changes in task demands (i.e., knowledge, skills, and effort). The varied degree of task demands can serve as an explanation for the effects of task complexity on attitude and task performance of the individuals who perform the task.

We adopted Hackman's task framework to examine the impact of task complexity. Hackman (1969a) noted that "*the magnitude of behavioral effects associated with process-output links must be nearly zero as a person begins a new task, but it grows over time to become the most important of the four types of task-based influence*" (p. 442). Moreover, based on activation theory (Scott, 1966), Campbell (1988) posited that "*to the extent an objectively complex task implies a greater number of stimulus sources, more uncertainty, and so forth, it will create a heightened sense of arousal within the individual*" (p. 48). Hence, of four types of task impacts, the process-outcome links and level of activation (i.e., task complexity) are of most relevance and interest to assessing the effect of task complexity.

Since the process-outcome links denote behavior requirements, McGrath's task circumplex was used to define the behavior requirement associated with our experimental task (i.e., puzzle). The puzzle task requires team members to solve a problem with a correct answer or solution; therefore, this task falls under the intellective task category according to McGrath's task circumplex. Furthermore, the puzzle task involves cooperation among team members in solving the problem with a correct answer.

Task complexity influences group behavior and outcomes by changing the level of cognitive and physiological arousal or activation. A performer's level of activation affects the actual "process" of behavior in the performance sequence (Hackman, 1969a).

Outcomes derived from the performance process can be either "personal" outcomes or "performance" outcomes (Hackman, 1969b). In this study, the dependent variables or outcomes are trust, attraction to team, and team process satisfaction. These variables are related to personal outcomes. Hackman (1969a; 1969b) noted that a trial outcome need not exist for every task. In the current study, subjects were allowed to solve the puzzle task in one attempt; thus, the notion of a trial outcome would be irrelevant.

Thus, as illustrated in **Figure 4.1**, we derived a research framework which was built on the combination of Hackman's task framework and McGrath's task circumplex to examine the effect of task complexity on trust, attraction to team, and team process satisfaction.

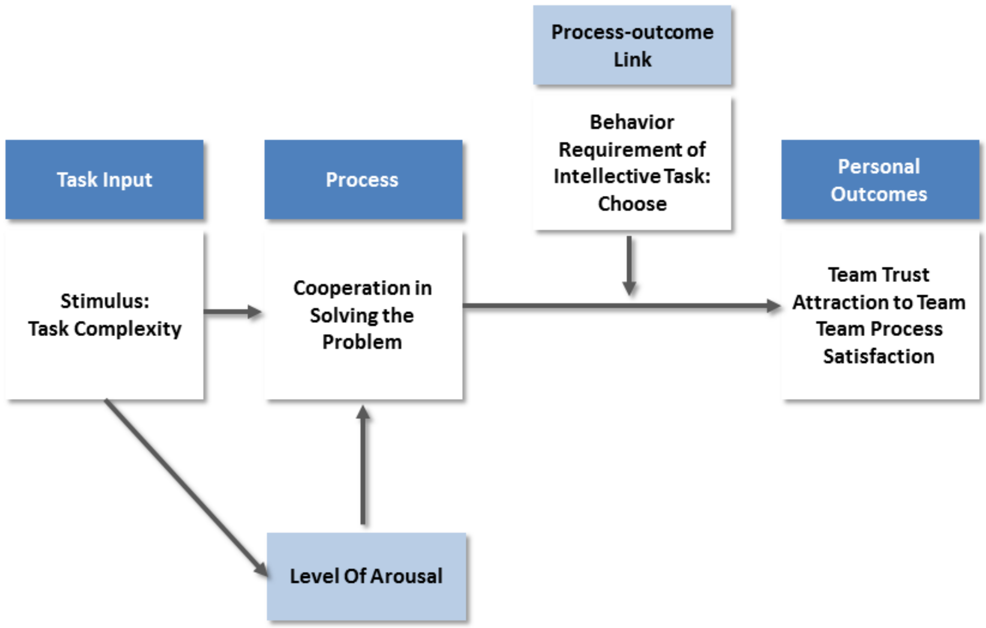


Figure 4.1: Research Framework

4.2 Team Trust

Interestingly, Mayer et al. (1995) argued that the level of trust may be constant across any given trustor, but the degree to which trust is developed will be determined by contextual factors (e.g., situations, the stake involved, the balance of power in the relationship). According to Mayer et al. (1995), "*the trustor perception and interpretation of the context of the relationship will affect both the need for trust and the evaluation of trustworthiness*" (p. 727). Accordingly, we would expect that different levels of task complexity result in varied levels of team trust between simple-task teams and complex-task teams.

Past research has shown that virtual teams are able to swiftly develop trust when they do not have a sufficient amount of time to gradually develop trust (Jarvenpaa & Leidner, 1999; Jarvenpaa, Knoll, & Leidner, 1998). This particular type of trust is labeled as "*swift trust*." Meyerson et al. (1996) suggested that swift trust was established when team members presume that others are trustworthy at the beginning of the project. We would expect that team members establish swift trust at the very outset of the task performance.

The highpoint of cognition-based trust is reached "when social actors no longer need or want any further evidence or rational reasons for their confidence in the objects of trust" (Lewis & Weigert, 1985, p. 970). Thus, cognitive-based trust relies on information and develops through communications among team members. In the present study, the puzzle task is considered an intellective task in accordance with McGrath's task circumplex. Since the intellective task involves collaboration among team members, it is essential that they collaborate and communicate more with their team members as the complexity of the task increases. We would predict that the more team members communicate, the greater the level of team trust developed.

Wood (1986) and Campbell (1988) suggest that the more complex the task, the greater will be the demand on cognitive resources to perform the task. To accomplish the task, the task performer will need to invest the appropriate amount of cognitive resources required in order to match the level of complexity present in the task. Specifically, we would expect that the more complex the task, the greater will be the demand on cognitive resources to perform the task. When virtual team members carry out a collaborative task, they will need to invest the appropriate amount of cognitive resources needed to match the level of complexity present in the task.

In most cases, each team member will use their own perceptions of the task requirements, complexity, and performance requirements to make inferences about whether and how other team members will respond to the task. Indeed, in the virtual world setting, a team member can visibly perceive the degree to which others in the team contribute their effort to the task in response to cognitive demands imposed by the task, which, in turn, promotes trust among the team members. Hence, we hypothesize that:

Hypothesis 1*: Teams will have higher levels of team trust in a high-complexity task than in a low-complexity task.*

4.3 Attraction to Team

Building upon Van Bergen and Koekebakker's (1959) assertion, Evans and Jarvis (1980) define *attraction to group* as an individual's desire to identify with and be an accepted member of the group. They also claim that "*attraction to group might arise from the degree to which a member's needs are met in the group and/or the congruence between his or her expectations for the group and what actually occurs."* Attraction to group is defined as an interaction of a group member's motives which results in the individual either leaving or remaining in the group (Van & Koekebakker, 1959).

According to McGrath's (1984) task circumplex, in the present study, puzzle tasks are considered as intellective tasks (i.e., problem solving tasks). Intellective tasks require member to cooperate and contribute their individual efforts in order to arrive at the desired solution for a given problem. It is assumed that team members cooperate more with the other team members as the complexity of the task increases.

In general, group members who have been motivated to cooperate show more positive responses to each other, are more favorable in their perceptions, are more involved in the task, and have greater satisfaction with the task (Stendler, Damrin, & Haines, 1951). Futhermore, Georgas (1985) maintains that cooperation enhances interactions between team members such that they are more positive, friendly, accepting, favorable, helping and attentive, which are precursors to the formation of group attraction (Lott & Lott, 1965). Hence, attraction to a team would be enhanced when task complexity increases due to the increased demand and opportunity for collaboration, cooperation, and communication.

Researchers found that success in adversity, among other conditions, can heighten attraction to the team (Husting, 1996). Complex tasks require extra amount of work or input such as communication and coordination, which are often viewed as adversity or challenge. Team members have to work interdependently around the assigned task to meet the team's goals. Thus, going through the process of overcoming adversity in a complex task, team members feel more emotionally and affectively attached to the team and members in the team. Hence, we hypothesize that:

Hypothesis 2*: Teams will have higher levels of attraction to team in a high-complexity task than in a low-complexity task.*

4.4 Satisfaction with Team Process

Team process satisfaction refers to the affective and positive emotional reaction team members have with the ways (e.g., procedure, deliberation, etc.) they arrive at an outcome (Lowry et al., 2009; Reining, 2003).

Goal setting theory suggests that difficult goals are more motivating for individuals than easy goals. Locke (1968) reported that there is a positive relationship between goal difficulty and level of performance. Difficult goals pose a challenge to individuals, motivating them to use the task situation to improve their skills and prove their competence (Locke & Latham, 1990b).

In addition, complex tasks, by nature, demand more cognitive resources including skills, effort, and knowledge of the task performer (Schroder et al., 1967) as well as behavioral performance including information processing and the physical process of carrying out the task. As a result, completion of complex tasks, compared to simple ones, is perceived to be a greater accomplishment, leading to a higher level of positive emotional reaction to team collaboration, i.e., team process satisfaction. Therefore, we hypothesize that:

Hypothesis 3*: Teams will have higher levels of team process satisfaction in a high-complexity task than in a low-complexity task.*

Chapter 5
Quantitative Analysis

5.1 Research Methodology

5.1.1 Research Model

In this research, we examine the effect of task complexity on the following dependent variables: 1) *team trust*, 2) *attraction to team*, and 3) *team process satisfaction*. The research model is depicted in **Figure 5.1**.

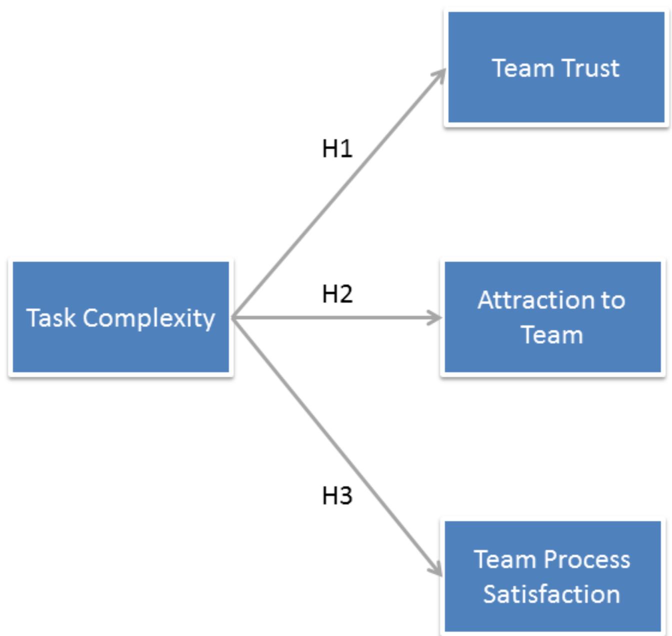


Figure 5.1: Research Model

5.1.2 Research Procedure

A controlled experiment was conducted to examine the hypotheses in Second Life, which is one of the most prominent virtual worlds. Second Life gives us the ability to freely create objects and manipulate different levels of task complexity. **Figure 5.2** shows the study's platform in Second Life.

Figure 5.2: The Study's Platform in Second Life

Subjects were randomly assigned to teams of two (i.e., dyads) to solve a puzzle task in Second Life. Members of each team did not know who was their other team member. Each team was randomly assigned to either the low- or high-complexity condition.

At the beginning of the experiment, subjects completed a short training task to familiarize with moving their avatars and the virtual objects in Second Life. Following the training, the dyads were asked to complete the puzzle task, which involved fitting puzzle pieces into a predefined pattern (i.e., to form a holistic picture). Team members were allowed to collaborate with their teammates using text chat offered in Second Life. Each team was given as much time as needed to complete the puzzle task.

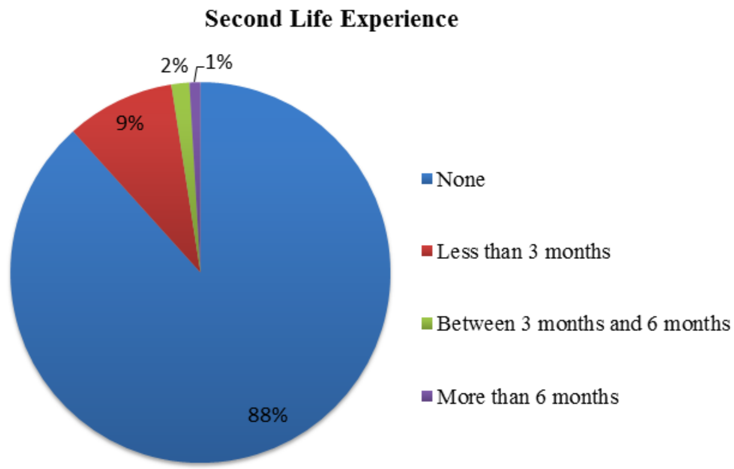
After the subjects completed the task, a post-study questionnaire was administered to assess the team process and their perceptions on the collaboration.

5.1.3 Subjects

A total of 216 subjects participated in this study. Subjects were recruited from students at a midwestern university. Demographic information of the subjects is presented in **Table 5.1**. The subjects' experience with the Internet and Second Life are shown in **Figure 5.3**, in which 88% of the subjects were using Second Life for the first time.

Table 5.1: Demographic Information

Gender	Female	35.17%
	Male	64.83%
Age	19	7.03%
	20-24	82.57%
	25-29	7.34%
	30-34	2.14%
	35-39	0.31%
	40-44	0.61%
Degree	High School	94.79%
	Bachelor	4.29%
	Graduate	0.92%



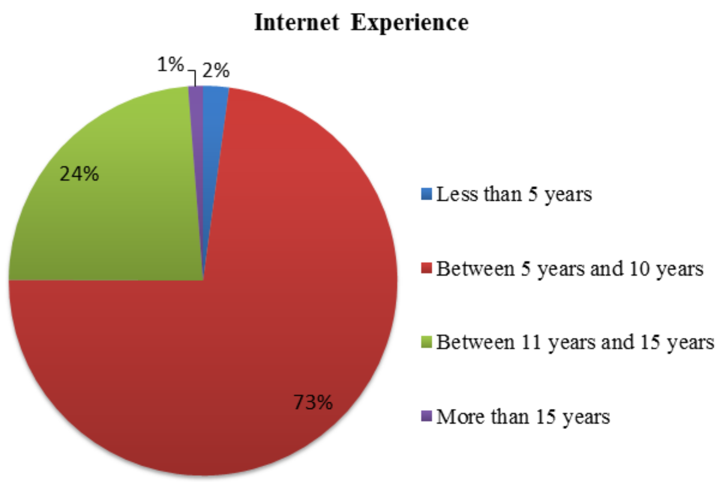


Figure 5.3: Subjects' Experience with the Internet and Second Life

5.1.4 Experimental Manipulation of Task Complexity

In our research, a puzzle was used as the experimental task. Puzzles of various types have been used in a variety of types of research because they are engaging for subjects, understood by the subjects, and the complexity of the task can be easily manipulated by varying the number of puzzle components (i.e., varying the component complexity) (Richardson & Vecchi, 2002).

Based on Campbell's (1988) framework, puzzles are classified as problem tasks because the puzzle consists of a multiplicity of paths to achieve a desired outcome. Because task complexity is a function of the number of potential paths to the desired outcome, the level of task complexity is increased by increasing the number of possible paths to arrive at the desired outcome. In other words, by increasing the number of pieces of a puzzle, the level of task complexity is increased.

We varied the levels of task complexity by varying the number of puzzle pieces. Specifically, the low-complexity task consists of six (i.e., 2 x 3) puzzle pieces while the high-complexity task consists of twenty-four (i.e., 4 x 6) puzzle pieces. In both cases, the image created from the puzzle pieces were the same (i.e., a picture from a popular animated movie). **Figure 5.4** and **Figure 5.5** show examples of assembled low- and high-complexity versions of the puzzle.

Figure 5.4: Low-Complexity Task/Puzzle

Figure 5.5: High-Complexity Task/Puzzle

5.1.5 Measurement

We adapted validated scales from prior research examining trust, attraction to team, and team process satisfaction. All question responses were recorded on a 9-point scale. **Table 5.2** shows the survey items utilized to assess the dependent variables. Team Trust and Attraction to Team were assessed using the Likert scale and Team Process Satisfaction was assessed using the semantic differential scale.

Table 5.2: Measurement Items

Construct	Measurement Items
Team Trust (adapted from Jarvenpaa, Knoll and Leidner (1998))	1. I could rely on the teammate with whom I worked. 2. We have confidence in one another in my team. 3. We were usually considerate of one another's feelings in my team. 4. My group has no "team spirit." (reverse-coded)
Attraction to Team (adapted from Evan and Jarvis (1986))	1. I would want to remain a member of this team. 2. I like this team. 3. I feel involved in what is happening in this team. 4. In spite of individual difference, a feeling of unity exists in this team. 5. Compared to other teams I know of, I feel this team is better than most. 6. It makes a difference to me how this team's efforts turn out.
Team Process Satisfaction (adapted from Green and Taber (1980))	How would you describe your team's process? 1. Very inefficient … very efficient 2. Very uncoordinated … very coordinated 3. Very confusing … very understandable 4. Very dissatisfying … very satisfying

5.2 Data Analysis

5.2.1 Factor Analysis

In this research, a factor analysis using the Principal Components method with Varimax rotation was conducted to assess the validity of the constructs.

Convergent validity refers to the extent to which multiple measures of a construct agree with one another; and discriminant validity refers to the extent to which measures of distinct constructs are different from each other (Carmines & Zeller, 1979). Items adequately measuring a construct should exhibit high factor loadings on the construct and low factor loadings on other constructs.

The results of the factor analysis for the endogenous variables (team trust, attraction to team, and team process satisfaction) provide evidence for convergent and discriminant validities of the constructs (see **Table 5.3**).

Table 5.3: Results of Factor Analysis

Items		Construct	
	Team Trust	**Attraction to Group**	**Team Process Satisfaction**
Trust1	**.698**	.334	.371
Trust2	**.791**	.333	.260
Trust3	**.830**	.215	.001
Trust4	**.643**	.308	.272
AttractionGrp1	.220	**.866**	.219
AttractionGrp2	.305	**.866**	.154
AttractionGrp3	.272	**.867**	.148
AttractionGrp4	.347	**.810**	.077
AttractionGrp5	.021	**.721**	.270
AttractionGrp6	.181	**.756**	.181
SatProc1	.223	.124	**.742**
SatProc2	.209	.214	**.854**
SatProc3	.149	.241	**.820**
SatProc4	.059	.334	**.741**

Reliability tests using Cronbach's alpha coefficients were conducted to assess the internal consistency of the items for each construct.

Cronbach's alpha coefficient for the construct "team trust" (Trust) is 0.86, which exceeds Nunnally's (1978) threshold of 0.70. **Table 5.4** suggests that Cronbach's alpha coefficient for team trust will not improve even if one of the items is deleted. Therefore, the measurement for team trust with four items is highly reliable and adequate.

Table 5.4: Item-Total Statistics for Team Trust

Item	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Cronbach's Alpha if Item Deleted
Trust1	18.79	23.879	.79
Trust2	19.08	22.974	.77
Trust3	19.10	24.961	.84
Trust4	19.20	23.983	.86

Cronbach's alpha coefficient for the construct "attraction to team" (AttractionGrp) is 0.94. Six items were included to measure attraction to team. **Table 5.5** suggests that if the fifth item (AttractionGrp5) is removed, the Cronbach's alpha coefficient will be increased to 0.95. However, the improvement of Cronbach's alpha is negligible. Hence, we decided to keep the fifth item.

Table 5.5: Item-Total Statistics for Attraction to Team

Item	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Cronbach's Alpha if Item Deleted
AttractionGrp1	30.79	70.611	.92
AttractionGrp2	30.60	70.544	.92
AttractionGrp3	30.68	71.852	.92
AttractionGrp4	30.94	73.510	.92
AttractionGrp5	31.31	75.064	.95
AttractionGrp6	30.97	74.452	.94

Cronbach's alpha coefficient for the construct "team process satisfaction" (SatProc) is 0.90, which exceeds Nunnally's (1978) threshold of 0.70. **Table 5.6** suggests that Cronbach's alpha coefficient for team process satisfaction will not improve even if one of the items is deleted. Therefore, the measurement for team process satisfaction with four items is highly reliable and adequate.

Table 5.6: Item-Total Statistics for Team Process Satisfaction

Item	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Cronbach's Alpha if Item Deleted
SatProc1	18.87	21.347	.89
SatProc2	19.54	19.930	.85
SatProc3	18.91	22.646	.86
SatProc4	18.81	23.504	.88

Table 5.7 presents a summary of Cronbach's alpha coefficients for measurement of the three dependent variables. Since Cronbach's alphas for team trust, team process satisfaction, and attraction to group/team exceed Nunnally's (1978) threshold of 0.70, all of the measurements are highly reliable.

Table 5.7: Cronbach's Alpha Coefficients

Construct	Cronbach's Alpha
Team trust	.86
Attraction to team	.94
Team process satisfaction	.90

5.2.2 Aggregation of the Measures

Before the relationships among variables can be assessed, the appropriateness of aggregating the individual measures to the group level must be demonstrated. George and James (1993) stated that the critical test for the appropriateness of aggregation is the within-group agreement on the variable examined. Consistent with Hyatt and Ruddy (1997) and Stewart and Barrick (2000), George and James (1993) and James, Demaree, and Wolf's (1984) method is appropriate for estimating the r_{wg} index of within-group agreement. This technique estimates the extent of agreement of group members in rating a given target (e.g., team members' ratings of team trust). If the average r_{wg} score of the scale is greater than .70, aggregation of individuals' scores to the group level is warranted (Kozlowski & Hattrup, 1992). Based on the criteria, all data were analyzed at the group level. The averages (r_{wg}) across group for team trust, team process satisfaction, and attraction to group are listed in **Table 5.8**.

Table 5.8: Average r_{wg} for Each Measure

Measurement	r_{wg}
Team trust	.86
Team process satisfaction	.86
Attraction to team	.83

5.2.3 Manipulation Check

A one-way ANOVA was used to test the effectiveness of the task complexity manipulation. A 5-item scale of subjective task complexity (Cronbach's alpha = .93) was adopted from Maynard and Hakel (1997). The manipulation check yielded a significant effect for levels of task complexity, $F(1, 81) = 20.73$, $p < .001$. Subjects in the high-complexity condition (*M* = 4.90, *SD* = 1.44) perceived their task to be more complex than did the subjects in the low-complexity condition (*M* = 3.54, *SD* = 1.09). We, hence, deemed the task complexity manipulation to be successful.

5.2.4 Control Variable

Propensity to trust is a personality trait that varies across individuals where some people are more likely or willing to trust others (Mayer et al., 1995). When there is no available information regarding team members, propensity to trust is considered to be an important factor affecting team trust that will subsequently be manifested among team members (Jarvenpaa et al., 1998; Mayer, et al. , 1995). We adapted the measurement scales for propensity to trust from Jarvenpaa et al. (1998).

5.2.5 Hypothesis Testing

Team trust was examined by conducting an ANCOVA with propensity to trust as a covariate. The ANCOVA results indicate that there is a significant difference in team trust, $F(1, 104) = 4.96$, $p < .05$. As shown in **Table 5.9**, teams in the high-complexity condition reported higher team trust ($M = 6.63$, $SD = 1.25$) as compared to teams in the low-complexity condition ($M = 6.10$, $SD = 1.28$).

Attraction to the team was examined by conducting a one-way ANOVA. As shown in **Table 5.9**, the results indicate that there is no significant difference between the two levels of task complexity, $F(1, 106) = .18$, $p = .67$.

Team process satisfaction was examined by conducting a one-way ANOVA. Results indicate that there is a significant difference in team process satisfaction, $F(1, 106) = 5.49$, $p < .05$. As shown in **Table 5.9**, teams in the high-complexity condition reported higher team process satisfaction ($M = 6.60$, $SD = 1.18$) as compared to teams in the low-complexity condition ($M = 6.08$, $SD = 1.11$).

Table 5.9: Experimental Results

Dependent Variable	Low Task Complexity (*n* = 56)		High Task Complexity (*n* = 52)		Total (*n* = 108)		ANOVA	
	M	**SD**	**M**	**SD**	**M**	**SD**	**F**	**Sig.**
Team trust	**6.10**	1.28	**6.63**	1.25	6.35	1.28	4.96	**.02**
Attraction to team	6.13	1.34	6.25	1.32	6.19	1.32	.18	.67
Team process satisfaction	**6.08**	1.11	**6.60**	1.18	6.33	1.67	5.49	**.02**

5.3 Secondary Data Analysis

5.3.1 Trust as a Mediator

Powell, Piccoli, and Ives (2004) suggested that trust is an important team process for virtual team effectiveness. Also, there is a positive link between team process and outcomes in terms of satisfaction. High levels of trust reduce barriers to communication and promote team satisfaction (Mitchell & Zigurs, 2009). The results of this study have shown that an increase in the level of task complexity escalate the degree of team trust. In addition, prior research in virtual teams has indicated that trust is a foundation for team effectiveness by fostering team satisfaction. Thus, trust could be a possible mediator between task complexity and team satisfaction (see **Figure 5.6**).

Figure 5.6: Trust as a Mediator

Accordingly, we examined trust as a mediator of task complexity effects on team process satisfaction using a procedure described by Baron and Kenny (1986). To test team trust as a mediator, we first examine whether task complexity has a significant effect on team trust and on team process satisfaction, and whether team trust has an effect team process satisfaction. If these paths are significant, we examine the effects of task complexity on team process satisfaction after controlling for team trust.

As shown in **Table 5.9**, the results indicate that task complexity has a significant effect on team trust, (1, 104) = 4.96, $p < .05$. Teams in the high-complexity condition reported higher level of team trust (M = 6.63, SD = 1.25), as compared to teams in the low-complexity condition (M = 6.10, SD = 1.28).

Additionally, as shown in **Table 5.9**, the results indicate that task complexity has a significant effect on team process satisfaction, $F(1, 106) = 5.49$, $p < .05$. Teams in the high-complexity condition reported higher level of team process satisfaction (M = 6.60, SD = 1.18), as compared to teams in the low-complexity condition (M = 6.08, SD = 1.11).

Finally, the results from a regression analysis (see **Table 5.10**) reveal that team trust has a significant effect on team process satisfaction ($R^2 = .61$, $\beta = .55$, $t = 7.86$, $p < .01$). Teams that reported higher team trust had higher team process satisfaction.

Table 5.10: Results of Regression of Team Process Satisfaction

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	2.82	.46		6.20	.00
Team trust	.55	.07	.61	7.86	.00

To test team trust as a mediator, task complexity was entered into the regression equation after controlling for the effects of team trust. **Table 5.11** indicates that the effect of task complexity when controlled for team trust is not significant.

Table 5.11: Results of Hierarchical Regression Controlling for Team Trust

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	2.71	.46		5.87	.00
Task complexity	.12	.09	.10	1.29	.20
Team trust	.53	.07	.59	7.45	.00

Hence, the results indicate that there is a mediating effect of team trust on team process satisfaction. In other words, as the task complexity increases, trust in the team is also increased, which results in higher team process satisfaction.

5.4 Discussions and Implications

This study empirically examines the effect of task complexity in virtual team collaboration in a virtual world (i.e., Second Life). The findings suggest that, as expected, an increase in task complexity can enhance team trust and team process satisfaction.

In this study, team members did not have prior working relationships with their teammates, and they had a very short period of time to collaborate with their teammates. In the group cohesion literature, it is argued that team members' perceptions about their group are likely to be influenced if they have substantial prior social or task experience with other group members as compared to joining and working with a group where there is no prior experience working together (Casey-Campbell & Martens, 2009). Accordingly, this could explain why there is no significant effect of task complexity on attraction to team in this study. Due to the short time duration of this study where team members have no prior history or working relationship, there may not be enough opportunity to develop attraction towards the team.

Consistent with prior studies (e.g., Jarvenpaa et al., 1998; Jarvenpaa & Leidner, 1999), the findings of the current study suggest that virtual teams are able to swiftly develop high levels of trust when they have to accomplish a common task with time pressure or within a limited time frame. In this study, the teams were randomly formed prior to the start of the experiment; however, the team trust indicators have a mean of 6.10 (out of 7) for low- complexity task and 6.63 (out of 7) for high-complexity task. This indicates that team members who are unknown to each other can develop swift trust in a virtual world environment. This rapid trust formation is likely due to the embodied representation of the users which fosters higher levels of involvement in the task and interactions with the other social actors (Mennecke et al,, 2011).

These results offer useful implications for team facilitators and team leaders. Specifically, to foster teamwork and team development, our findings suggest that more complex tasks will improve team member perceptions about other team members. The reasons for these findings probably relate to the interdependence that is needed when team members engage in more complex endeavors. For example, for a simple task, less interaction and cooperation is needed to complete the exercise. In this case, the small number of pieces involved in the low-complexity task would have been easily completed by the team members in a short amount of time and with less of a requirement for coordination and cooperation between team members. This lower level of reliance and involvement with each other would lessen the requirement to trust. A practical implication of this is that a task needs to be sufficiently complex to provide the opportunity for interaction and coordination of acts to take place during task completion.

These results also have practical implications for team building. The findings in this study are particularly relevant for geographically dispersed teams. An increasing number of organizations are globalizing and have organizational members situated in non-proximate locations. With virtual worlds, team building can be conducted virtually. Additionally, it appears that team trust and team process satisfaction are enhanced with more complex tasks; therefore, an important implication of this study is that facilitators and team leaders should consider the relative complexity of team building exercises when using such tools to build trust within their teams.

5.5 Limitations and Future Research

In this research, we manipulated task complexity such that the complexity levels are within a manageable range. The results could have been different if task complexity is above a certain ‘manageable’ threshold where cooperation and engagement in the task and other behaviors supporting teamwork break down or falter. To keep the task manageable and reasonable for subjects and to examine trust in a comparable range of task contexts in future research, we limited the complexity of the task in this research to a manageable cognitive level in order to examine the relative effects of task complexity on team collaboration. Future research may examine the effects of complexity of different types of tasks including cognitive, affective, and psychomotor tasks.

In this study, the puzzle task of our study embedded only one dimension of task complexity – component complexity. It is noteworthy that future research assesses the effect of task complexity with regard to other types of task complexity (e.g., coordinative complexity and dynamic complexity).

Another possible limitation of this study is that we examined groups of only two members. In general, group size may influence division of labor in teams and the degree of social loafing. Also, group size could be a moderator of the relationship between task complexity and team behavior.

Finally, this study represents a cross-sectional (or snapshot) view of short-duration teams; therefore, longitudinal studies would be helpful and appropriate for developing a more complete understanding of how team trust and team process satisfaction evolve as teams develop.

Chapter 6
Conclusions and Contributions

Team collaboration in virtual worlds is an important topic that deserves more attention and research. This research examines task complexity and empirically tests three hypotheses related to team collaboration in a virtual world, Second Life. The findings suggest that team trust and team process satisfaction increase with the complexity of the task. High task complexity results in higher team trust and team process satisfaction. Attraction to the team, on the other hand, is not significantly affected by task complexity, which may have resulted from the lack of any prior relationship between team members and the very short duration of the task. Team members may require an appropriate or greater amount of time to form team identification and to develop attraction towards the team.

These findings are interesting and contribute to the team building literature. For example, to the best of our knowledge, this is the first study that has examined team trust in combination with task complexity. Team managers may take advantage of affordances provided by Second Life in order to design and create team building exercises that utilize task complexity to enhance trust and satisfaction among team members.

Additionally, these results were observed in the context of virtual worlds and this research builds on prior research examining team interaction in these and traditional venues. As one of the first research studies to examine team collaboration in virtual worlds, this study contributes to the literature on collaboration and use of virtual worlds.

References

Altman, I. (1966). Aspects of the criterion problem in small group research: Behavioral domains to be studied. *Acta Psychologica*, *25*, 101-131.

Bainbridge, W. (2007). The scientific research potential of virtual worlds. *Science*, 472-476.

Baron, R. M., & Kenny, D. A. (1986). The moderator-mediator variable distinction in social psychological research: Conceptual, strategic, and statistical considerations. *Journal of Personality and Social Psychology*, 1173-1182.

Beal, D. J., Cohen, R. R., Burke, M. J., & McL, C. L. (2003). Cohesion and performance in groups: a meta-analytic clarification of construct relations. *Journal of Applied Psychology, 88*, 989-1004.

Boon, S. D., & Holmes, J. G. (1991). The dynamics of interpersonal trust: resolving uncertainty in the face of risk. In R. A. Hinde, & J. Groebel, *Cooperation and Prosocial Behavior* (pp. 190-211). Cambridge, England: Cambridge University Press.

Campbell, D. J. (1988). Task complexity: A review and analysis. *Academy of Management Review*, *13*(1), 40-52.

Campbell, D. J., & Gingrich, K. (1986). The interactive effects of task complexity and participation on task performance: A field experiment. *Organizational Behavior and Human Decision Process, 38*, 162-180.

Campion, M. A., Medsker, G. J., & Higgs, A. C. (1993). Relations between work group characteristics and effectiveness: Implications for designing effective work groups. *Personnel Psychology, 46*(4), 823-847.

Campion, M. A., Papper, E. M., & Medsker, G. J. (1996). Relations between work team characteristics and effectiveness: A replication and extension. *Personnel psychology, 49*(2), 429-452.

Carey, J. M., & Kacmer, C. J. (1997). The impact of communication mode and task complexity on small group performance and member satisfaction. *Computers in Human Behavior, 13*(1), 23-49.

Carmines, E. G., & Zeller, R. A. (1979). *Reliability and Validity Assessment.* Beverly Hills: Sage.

Cartwright, D. (1968). The nature of group cohesiveness. In D. Cartwright, & A. Zander, *Group Dynamics: Research and Theory* (pp. 91-109). New York: Harper & Row.

Casey-Campbell, M., & Martens, M. L. (2009). Sticking it all together: A critical assessment of the group cohesion--performance literature. *International Journal of Management Reviews, 11*(2), 223-246.

Castronova, E. (2001). Virtual Worlds: A First-Hand Account of Market and Society on the Cyberian Frontier. *The Gruter Institute Working Papers on Law, Economics, and Evolutionary Biology, 2*.

Churchill, E. F., & Snowdon, E. (1998). Collaborative Virtual Environments: An introductory review of issues and systems. *Virtual Reality, 3*(1), 3-15.

Cook, J., & Wall, T. (1980). New work attitude measures of trust, organizational commitment and personal need non-fulfilment. *Journal of Occupational Psychology*, British Psychological Society.

Davis, A., Murphy, J., Owens, D., Khazanchi, D., & Zigurs, I. (2009). Avatars, people, and virtual worlds: Foundations for research in metaverses. *Journal of the Association for Information Systems, 10*(2), 90-117.

Dorfman, P. W., & Stephen, W. G. (1984). The effects of group performance on cognitions, satisfaction, and behavior: A process model. *Journal of Management, 10*(2), 173-192.

Dubé, L., & Paré, G. (2004). The Multifaceted nature of virtual teams. In D. Pauleen (Ed.), *Virtual Teams: Projects, Protocols, and Processes.* Idea Group Publishing.

Ellis, J. B., Luther, K., Bessiere, K., & Kellogg, W. A. (2008). Games for virtual team building. *Proceedings of the 7th ACM conference on Designing interactive systems* (pp. 295-304). ACM.

Evans, C. R., & Jarvis , P. A. (1980). Group cohesion: a review and reevaluation. *Small Group Behavior*, *11*, 359-370.

Evans, N. J., & Jarvis, P. A. (1986). The group attitude scale. *Small Group Research, 17*(2), 203.

Ferguson, G. A. (1956). On transfer and human ability. *Canad. J. Psychol*, *10*, 121-131.

Georgas, J. (1985). Cooperative, competitive and individual problem-solving in sixth grade Greek children. *European Journal of Social Psychology, 15,* 67-77.

George, J. M., & James, L. R. (1993). Journal of Applied Psychology. *Personality, affect, and behavior in groups revisited: Comment on aggregation, levels of analysis, and a recent application of within and between analysis*, *78*(5), 798-804.

Gerhard, M., Moore, D., & Hobbs, D. (2004). Embodiment and copresence in collaborative interfaces. *International Journal of Human-Computer Studies, 61*(4), 453-480.

Green, S. G., & Taber, T. D. (1980). The effects of three social decision schemes on decision group process. *Organizational Behavior and Human Performance, 25*(1), 97-106.

Gross, N., & Martin, W. E. (1952). On group cohesiveness. *American Journal of Sociology, 57*(6), 546-564.

Gully, S. M., Devine, D. J., & Whitney, D. J. (1995). A meta-analysis of cohesion and performance: Effects of levels of analysis and task interdependence. *Small Group Research, 26,* 497-520.

Hackman, J. R. (1969a). Nature of the task as a determiner of job behavior. *Personnel Psychology, 22*(4), 435-444.

Hackman, J. R. (1969b). Toward understanding the role of tasks in behavioral research. *Acta Psychologica, 31*, 97-128.

Hackman, J. R., & Morris, C. G. (1975). Group tasks, group interaction process, and group performance effectiveness: A review and proposed integration. *Advances in Experimental Social Psychology*, 45-99.

Hare, A. R. (1962). *Handbook of Small Group Research.* New York: Free Press.

Hendaoui, A., Limayem, M., & Thompson, C. W. (2008). 3D social virtual worlds: Research issues and challenges. *IEEE INTERNET COMPUTING*, 88-92.

Husting, P. M. (1996). Leading work teams and improving performance. *Nursing Management, 27*(9), 35.

Hyatt, D. E., & Ruddy, T. M. (1997). An examination of the relationship between work group characteristics and performance: Once more into the breech. *Personnel Psychology, 50*(3), 553-585.

James, L. R., Demaree, R. G., & Wolf, G. (1984). Estimating within-group interrater reliability with and without response bias. *Journal of Applied Psychology, 69*(1), 85-98.

Jarvenpaa, S. L., & Leidner, D. E. (1999). Communication and trust in global virtual teams. *Organization Science, 10*(6), 791-815.

Jarvenpaa, S. L., Knoll, K., & Leidner, D. E. (1998). Is anybody out there? Antecedents of trust in global virtual teams. *Journal of Management Information Systems, 14*(4), 29-64.

Kahai, S. S., Carroll, E., & Jestice, R. (2007). Team collaboration in virtual worlds. *The DATA BASE for Advances in Information Systems, 38*(4), 61-68.

Kanawattanachai, P., & Yoo, Y. (2002). Dynamic nature of trust in virtual teams. *Journal of Strategic Information Systems, 11*, 187-213.

Khazanchi, D., & Zigurs, I. (2006). Patterns for effective management of virtual projects: Theory and evidence. *International Journal of E-Collaboration, 2*(3), 25-49.

Kock, N. (2000). Benefits for virtual organizations from distributed groups. *Communications of the ACM, 43*(11), 107-112.

Kock, N. (2008). E-collaboration and e-commerce in virtual worlds: The potential of Second Life and World of Warcraft. *International Journal of e-Collaboration, 4*(3), 1-13.

Korsgaard, M. A., Picot, A., Wigand, R. T., Welpe, I. M., & Assmann, J. J. (2010). Cooperation, coordination, and trust in virtual teams: insights from virtual games. In W. Bainbridge, *Online Wolrds: Convergence of the Real adn the Virtual* (pp. 253-264).

Kozlowski, S. W., & Hattrup, K. (1992). A disagreement about within-group agreement: Disentangling issues of consistency versus consensus. *Journal of Applied Psychology*, *77*(2), 161-167.

Kozlowski, S. W., & Ilgen, D. R. (2006). Enhancing the effectiveness of work groups and teams. *Psychological Science in the Public Interest, 7*, 77-124.

Lewis, J. D., & Weigert, A. (1985). Trust as a social reality. *Social Forces, 63*(4), 967-985.

Lipnack, J., & Stamps, J. (1997). *Virtual teams: Reaching across space, time, and organizations with technology*. New York: John Wiley and Sons.

Locke, E. A. (1968). Toward a theory of task motivation and incentives. *Organizational Behavior and Human Performance, 3*, 157-189.

Locke, E. A., & Latham, G. P. (1990a). *A Theory of Goal Setting Task Performance.* NJ: Prentice Hall.

Locke, E. A., & Latham, G. P. (1990b). Work motivation and Satisfaction: Light at the end of the tunnel. *Psychological Science, 1*(4), 240-246.

Lott, A. J., & Lott, B. E. (1965). Group cohesiveness as interpersonal attraction: A review of relationships with antecedent and consequence variables. *Psychological Bulletin*, *60*(4), 259-309.

Lowry, P. B., Romano, N. C., Jenkins, J. L., & Guthrie, R. W. (2009). The CMC interactivity model: how interactivity enhances communication quality and process satisfaction in lean-media groups. *Journal of Management Information Systems, 26*(1), 155-196.

Lurey, J. S., & Raisinghani, M. S. (2001). An empirical study of best practices in virtual teams. *Information and Management, 38*(8), 523-544.

Mayer, R. C., Davis, J. H., & Schoorman, F. D. (1995). An integrative model of organizational trust. *Academy of Management Review, 20*(3), 709-734.

Maynard, D. C., & Hakel, M. D. (1997). Effects of objective and subjective task complexity on performance. *Human Performance, 10*(4).

McAllister, D. J. (1995). Affect- and cognition-based trust as foundations for interpersonal cooperation in organizations. *Academy of Management Journal, 38*, 24-59.

McGrath, J. E. (1984). *Groups: Interaction and Performance.* New Jersey: Prentice-Hall.

McGrath, J. E., & Altman, I. (1966). *Small group research: A synthesis and critique of the field.* New York: Holt.

Mennecke, B. E., & Wheeler, B. C. (1993). Tasks matter: Modeling group task processes in experimental CSCW research. *System Sciences: Proceeding of the Twenty-Sixth Hawaii International Conference, 4,* pp. 71-80.

Mennecke, B. E., Triplett, J. L., Hassall, L. M., Conde, Z. J., & Heer, R. (2011). An examination of a theory of embodied social presence in virtual worlds. *Decision Sciences, 42*(2), 413-450.

Messinger, P. R., Stroulia, E., Lyons, K., Bone, M., Niu, R., Smirnov, K., et al. (2009). Virtual worlds — past, present, and future: New directions in social computing. *Decision Support Systems*.

Meyerson, D., Weick, K. E., & Kramer, R. M. (1996). Swift trust and temporary groups. In R. M. Kramer, & T. R. Tyler (Eds.), *Trust in Organizations: Frontiers of Theory and Research* (pp. 166-195). Thousand Oaks, CA: Sage Publications.

Mitchell, A., & Zigurs, I. (2009). Trust in virtual teams: solved or still a mystery? *The DATA BASE for Advances in Information Systems, 40*(3), 61-83.

Mullen, B., & Copper, C. (1994). The relation between group cohesiveness and performance: An integration. *Psychological bulletin, 115*(2), 210.

Nunnally, J. (1978). *Psychometric Theory*. New York: McGraw-Hill.

Peters, L. M., & Manz, C. C. (2007). Identifying antecedents of virtual team collaboration. *Team Performance Management, 13*(3/4), 117-129.

Picot, A., Assmann, J. J., Korsgaard, M. A., Welpe, I. M., Gallenkamp, J. V., & Wigand, R. T. (2009). A multi-level view of the antecedents and consequences of trust in virtual leaders. *AMCIS 2009 Proceedings*, (p. 271).

Pinsonneault, A., & Caya, O. (2005). Virtual teams: What we know, what we don't know. *International Journal of E-Collaboration, 1*(3), 1-16.

Poole, M. S., Siebold, D. R., & McPhee, R. D. (1985). Group decision-making as a structurational process. *Quarterly Journal of Speech, 71*(1), 74-102.

Powell, A., Piccoli, G., & Ives, B. (2004). Virtual teams: A review of current literature and directions for future research. *The DATA BASE for Advances in Information Systems*, *35*(1), 6-36.

Reining, B. A. (2003). Toward an understanding of satisfaction with the process and outcomes of teamwork. *Journal of Management Information Systems*, *19*(4), 65-83.

Richardson, J. T., & Vecchi, T. (2002). A jigsaw-puzzle imagery task for assessing active visuospatial processes in old and young people. *Behavior Research Methods, Instruments, and Computers, 34*(1), 69-82.

Robert, L. P., Dennis, A. R., & Hung, Y. C. (2009). Individual swift trust and knowledge-based trust in face-to-face and virtual team members. *Journal of Management Information Systems*, *26*(2), 241-279.

Roby, T. B., & Lanzetta, J. T. (1958). Considerations in the analysis of group tasks. *Psychological Bulletin*, *55*(2), 88-101.

Sagi, P. C., Olmstead, D. W., & Atelsek, F. (1955). Predicting maintenance of membership in small groups. *The Journal of Abnormal and Social Psychology, 51*(2), 308.

Sarker, S., Valacich, J. S., & Sarker, S. (2000). An Exploration of Trust in Virtual Teams Using Three Perspectives. *AMCIS 2000 Proceedings.*

Schroder, H., Driver, M., & Streufert, S. (1967). *Human information processing.* New York: Holt, Rinehart and Winston.

Schroeder, R., Heldal, I., & Tromp, J. (2006). The usability of collaborative virtual environments and methods for the analysis of interaction. *Presence: Teleoperators and Virtual Environments, 15*(6), 655-667.

Scott, W. E. (1966). Activation theory and task design. *Organizationaly Behavior and Human Performance, 1*, 3-30.

Shaw, J. D., Duffy, M. K., & Stark, E. M. (2000). Interdependence and preference for group work: main and congruence effects on the satisfaction and performance of group members. *Journal of Management, 26*(2), 259-279.

Shaw, M. E. (1981). *Group Dynamics: The Psychology of Small Group Behavior.* New York: McGraw-Hill Book Company.

Siau, K., Nah, F. F.-H., Mennecke, B. E., & Schiller, S. Z. (2010). Co-creation and collaboration in a virtual world: A 3D visualization design project in second life. *Journal of Database Management, 21*(4), 1-13.

Slater, M., Sadagic, A., Usoh, M., & Schroeder, R. (2000). Small group behaviour in a virtual and real environment: A comparative study. *Presence: Teleoperators and Virtual Environments, 9*(1), 37-51.

Smith, K. G., Smith, K. A., Olian, J. D., Sims, H. P., O'Bannon, D. P., & Scully, J. A. (1994). Top management team demography and process: The role of social integration and communication. *Administrative Science Quarterly, 39*(3), 412-438.

Steiner, I. D. (1966). Models for inferring relationships between group size and potential group productivity. *Behavioral Science, 11*(4), 273–283.

Stendler, C., Damrin, D., & Haines, A. C. (1951). Studies in cooperation and competition: The effects of working for group and individual rewards on the social climate of children's groups. *The Pedagogical Seminary and Journal of Genetic Psychology*.

Stewart, G. L., & Barrick, M. R. (2000). Team structure and performance: Assessing the mediating role of intra-team process and the moderating role of task type. *The Academy of Management Journal, 43*(2), 135-148.

Taylor, T. L. (2002). Living digitally: Embodiment in virtual worlds. In R. Schroeder (Ed.), *The Social Life of Avatars.* London, UK: Springer.

Van, B. A., & Koekebakker, J. (1959). Group cohesiveness in laboratory experiment. *Acta Psychologica, 16*, 81-98.

Wainfan, L., & Davis, P. K. (2004). *Challenges in Virtual Collaboration: Videoconferencing, Audioconferencing, and Computer-mediated communications.* Santa Monica, CA: RAND Corporation.

Wood, R. E. (1986). Task complexity: Definition of the construct. *Organizational Behavior and Human Decision Processes, 37*(1), 60-82.

Yee, N., & Bailenson, J. (2007). The proteus effect: The effect of transformed self-representation on behavior. *Human Communication Research, 33*(3), 271-290.

Zhao, Y., Wang, W., & Zhu, Y. (2010). Antecedents of the closeness of human-avatar relationships. *Journal of Database Management, 21*(2), 41-68.

Zigurs, I. (2003). Leadership in virtual teams: Oxymoron or opportunity? *Organizational Dynamics, 31*(4), 339-351.