PERSONALITY TRAITS AND PERFORMANCE
IN ONLINE GAME-BASED LEARNING:
COLLABORATIVE VERSUS INDIVIDUAL SETTINGS

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This dissertation is dedicated to my parents, Angel Lara and María Rodríguez, and to my siblings, Rosal, Juanca, and Mary Tere, for their continuing encouragement and support during my doctoral journey.
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PERSONALITY TRAITS AND PERFORMANCE IN ONLINE GAME-BASED LEARNING: COLLABORATIVE VERSUS INDIVIDUAL SETTINGS

Extant research indicates that, in face-to-face settings, cooperative learning and game-based learning strategies can be effective. However, in online settings (e.g., in distance education), there is a paucity of research in this area. This study was designed to investigate performance and attitudes of university students who played an educational game collaboratively at different online locations, compared with those playing individually. Relationships among player game performance and personality traits were examined, as well as differences in patterns of gameplay and attitudes about their learning experience.

Participants were randomly assigned either to an individual or to a collaborative online game setting. All participants played an abridged version of the Diffusion Simulation Game (DSG) repeatedly during an 80-minute period. Those in collaborative dyads were paired based on level of agreeableness (one of the personality traits in the Big Five Model). Cooperative learning strategies for dyads required positive interdependence, group monitoring, and individual accountability.

DSG sessions occurred virtually in Second Life and were digitally captured. Participants also completed a learning achievement test, personality trait questionnaire and an attitude survey. The DSG itself also stored turn-by-turn histories of each game played.
Results indicated that cooperative dyads significantly outperformed individual players. Participants in both settings agreed that they enjoyed playing the game and considered it an effective way to learn. The personality trait, conscientiousness, was positively correlated with game performance in the individual setting, whereas both extraversion and agreeableness were negatively correlated with performance in the collaborative setting.

Results from Analysis of Patterns in Time indicated that, in both settings, for games with the highest scores, participants conducted more turns that involved cognitive processes, when compared with games with the lowest scores. In the collaborative setting, games resulting in the highest scores occurred when players negotiated actively, in contrast to games ending with the lowest scores.

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CHAPTER I: INTRODUCTION

Statement of the Problem

Since the first decade of the 2000s, there has been a considerable increase in demand for online courses in the United States (Allen & Seaman, 2010). As online learning continues to proliferate, it is critical to investigate instructional strategies that have the ability to promote engagement, motivation, and learning among students taking courses in this environment. By relying on electronic communication media, online interaction differs from face-to-face interaction in several aspects such as the lack of social context cues (Culnan & Markus, 1987; Sproull & Kiesler, 1986), slower feedback immediacy (Daft & Lengel, 1984), and greater communication ambiguity (Kock, 2005).

Two instructional strategies that have proven effective in the traditional face-to-face environment are collaborative learning (Johnson & Johnson, 1991; Johnson, Johnson, & Smith, 1998a; Slavin, 1995) and game-based learning (Garris, Ahlers, & Driskell, 2002; Kirriemuir & McFarlane, 2004); however, there is a scarcity in the literature about the effectiveness and efficiency of the combination of these instructional strategies in the online environment. Moreover, collaborative activities are becoming more pervasive in distance education in spite of mixed results about evidence of their effectiveness (Anindito & Reimann, 2006) or being contrary to some distance learners’ preferences (Molenda, 2012). There is thus a need for further investigation regarding the effectiveness of collaborative approaches in specific contexts in the online environment.

According to psychology theorists, personality traits, such as the willingness to cooperate and socialize with others, have the potential to influence the quality and level
of effectiveness of the collaboration process (Furhnan, 1996; Kichuk & Wiesner, 1997). In general, teams composed of people who are more talkative, tolerant, sociable, cooperative, and gregarious tend to perform better field tasks than teams composed of introverted and laconic people (Bell, 2007); however, the relationship between personality traits and task performance varies depending on the nature of the task (Driskell, Hogan, & Salas, 1987). The present study was aimed at exploring whether some personality traits were related with performance when playing collaboratively an online educational game.

By integrating three main areas --computer-supported collaborative learning, game-based learning, and personality psychology-- this study intended to investigate the impact on learning of implementing a collaborative instructional strategy when playing an online educational simulation game. It also examined the relationship between learners’ performance and their personality traits, and the level of satisfaction and perceptions of learners using the game as an educational vehicle.

**Theoretical Framework**

In terms of collaborative learning, copious studies across all ages and academic levels and within a great variety of subject areas have demonstrated that learning is more effective when students work in teams rather than working individually in both face-to-face settings (Brush, 1997; Johnson & Johnson, 1991; Johnson et al., 1998a; Lou, Abrami, & d'Apollonia, 2001; Slavin, 1995; Springer, Stanne, & Donovan, 1999) and online settings (Ertl, Kopp, & Mandl, 2007; Gunawardena, 1995; Hall, 1997; Mergendoller, Bellisimo, & Maxwell, 2000). Merrill and Gilbert (2008) suggest that peer collaboration facilitates learning in a problem-centered approach because “it encourages
students towards a deeper processing of the information and a more careful examination of their assumptions” (p. 202). Theorists suggest that in order to promote cognitive benefits among all interacting participants it is essential to include certain elements within the collaboration process, such as positive interdependence, individual accountability, social skills, and group processing (Johnson, Johnson & Smith, 1998a; Slavin, 1995).

Additional studies, however, have demonstrated that when well-designed instruction is provided to all students, the learning gains are the same regardless of providing an individual or collaborative instructional setting (Brewer & Klein, 2006; Cole & Smith, 1993; Klein & Schnackenberg, 2000). For instance, Klein and Schnackenberg (2000) reported that in a study involving 122 undergraduate education majors, participants working individually in a short task (shorter than two hours) performed better and had more continuing motivation for working alone than participants working in dyads cooperatively. Based on these conflicting findings, it is necessary to conduct further studies that examine the effectiveness of collaboration learning strategies when used in short instructional tasks.

The field of computer-supported collaborative learning (CSCL) emerged to analyze and facilitate the collaboration and learning processes in computer-mediated communication. The goal of CSCL is to study how people can learn together with the help of computers (Stahl, Koschmann, & Suthers, 2006). CSCL combines the collaborative learning theory with the computer-mediated communication theory (CMC) (Harasim, 1989; Kirschner, 2002; Koschmann, 1994; Mayes & Neilson, 1995).
Research conducted in CSCL indicates that the implementation of collaborative learning in the online setting can be as effective or even more effective than collaboration in the face-to-face setting (Ertl, Kopp, & Mandl, 2007; Gunawardena, 1995; Hall, 1997). However, most of the CSCL studies have been conducted using asynchronous communication tools, such as discussion forums, or text-based synchronous communication, such as chat tools. There is a scarcity of studies investigating the use of collaborative learning in the online setting relying on synchronous verbal communication.

Psychology theorists suggest that personality factors have the potential to influence the level of effectiveness in teamwork (Furhnan, 1996; Kichuk & Wiesner, 1997). Personality traits are relatively permanent characteristics of individuals (Helmreich, 1984) that are mostly inherited and are not easily changed by interventions such as behavioral training (Kichuk & Wiesner, 1997). Hogan (1991) claims that the propensity of an individual to interact with others or to behave in a certain manner is a function of the individual’s personality, such as the level of extraversion or emotional stability.

The Big Five Model (or simply “The Big Five”) is a taxonomy of personality traits that has been generally accepted in the field of personality psychology (John, Naumann, & Soto, 2008). The Big Five includes five domains of related personality characteristics, namely agreeableness, conscientiousness, extraversion, neuroticism, and openness to new experience. Barrick and Mount (1991) provide the following descriptions for these domains: Agreeableness refers to concepts such as trusting, politeness, tolerance, and willingness to cooperate. Extraversion refers to the level of
sociability, gregariousness and assertiveness of individuals. Conscientiousness refers to the level of responsibility and reliability of an individual and it is also associated with concepts such as endurance or perseverance. Neuroticism also known as emotional stability refers to the level of anxiety, depression, and insecurity of an individual. Openness to new experience refers to the level of curiosity, creativity and broad-mindedness of an individual.

There are several studies that explore the effects of personality in team performance (Annelies, 2001; Kichuk, 1999; Miranda et al., 2006); however, in most of these studies the team members worked side by side at the same geographic location. There is a scarcity in the literature about the effect of personality traits in online collaboration, specifically in synchronous activities in which team members use verbal communication to solve an assigned problem.

In terms of game-based learning, Kirriemuir and McFarlane (2004) identify two main reasons for using games for instructional purposes: their power to engage and motivate, and their ability to facilitate learning through doing. Similarly, Garris et al. (2002) suggest that educators should be interested in using games in instruction because of the intensity of involvement and engagement they provide and for facilitating the shift to a learner-centered model. Well-designed games can provide a meaningful environment in which to develop critical thinking and problem-solving skills (Kiili, 2005).

Another reason for using games as learning experiences is that digital games and simulations are becoming progressively more ubiquitous to such a degree that they are now being identified as an integral part of our culture. Prensky (2001) labels the current generation as the “Game Generation.” In the United States, nearly all children and
teenagers have played a videogame and so have fifty percent of adults (van Eck, 2006). Furthermore, studies conducted on digital games and simulations in diverse fields have demonstrated their effectiveness as part of the learning process (Aldrich, 2005).

Digital simulation games provide an environment that mimics a real scenario thus facilitating learning in those situations that are too expensive or dangerous to conduct in real life. The advent of 3D virtual worlds and massive multiplayer online role playing games (MMORPGs) with integrated voice over IP and co-browsing capabilities has facilitated interaction among peers enabling synchronous communication with high quality sound. In these 3D environments, people interact with each other through avatars, which are three-dimensional graphical representations of players. Using avatars has the potential to lower inhibitions and increase social interactivity (Meadows, 2008).

In reviewing the literature, most current studies regarding 3D virtual worlds and MMORPGs focus mainly on analyzing players’ joint effort to accomplish a task (Steinkuehler, 2006) or exploring the use of social semiotics between avatars, space, and artifacts (Bardzell & Odom, 2008; Bardzell, 2010). However, there is a need for additional studies that explore the use of 3D virtual worlds to play educational games and that measure both gains in learning and the level of satisfaction while playing the game collaboratively.

**Definition of Terms**

The following terms and their connotations were used throughout this study:

Collaborative learning – this study used Roschelle and Teasley (1995) definition of collaboration which they define as “the mutual engagement of participants in a coordinated effort to solve the problem together” (p. 70). It is worth noticing that some
authors make a clear distinction between the terms collaborative learning and cooperative learning mentioning that these instructional strategies differ to the extent in which the task assigned is structured and external support is provided. However, in a realistic setting, these terms are complementary (Dillenbourg, 2002) because they refer in general to situations in which team members work together in order to achieve a common goal. In the present study these terms are used interchangeably as several authors have done (Dillenbourg, Baker, Blaye, & O’malley (1996); Kitchen & McDougall, 1998; Wessner & Pfister, 2007).

Computer supported collaborative learning (CSCL) – Koschmann (2002) defines CSCL as a “field of study centrally concerned with meaning and the practices of meaning making in the context of joint activity, and the ways in which these practices are mediated through designed artifacts” (p. 18). Moreover, Stahl, Koschmann, and Suthers (2006) state that CSCL is mainly concerned with studying how people can learn together with the help of computers.

Collaborative scripts – is a set of instructions that describe how the group members should interact, collaborate, and solve a problem or task assigned (O’Donnell & Dansereau, 1992). Examples of common collaborative scripts are problem-based learning, jigsaw, and fishbowl.

Second Life – is an online three-dimensional virtual world in which people can interact with others through graphical representations of themselves called avatars.
Context of the Study

This study used a modified version of a game called the “Diffusion Simulation Game” (DSG), which teaches concepts and strategies related to the diffusion of innovations theory, as instructional material (Molenda & Rice, 1979). The DSG version used allowed for multiple people playing the game collaboratively using the co-browsing capabilities of the 3D virtual world called Second Life.

A total of 44 native-English speaking undergraduate and graduate students from eleven different academic departments at Indiana University participated in the study. Half of the students were randomly assigned to play the DSG individually while the other half were assigned to play it collaboratively. Students assigned to the collaborative setting were paired, based on a personality survey that measured the Big Five personality traits, with other students that had similar level of agreeableness.

Students in both settings took a pre-test that measured their existing knowledge about the diffusion of innovations theory. All students were allotted 80 minutes to play the DSG as many times as they wanted and to restart the game at any point. In order to motivate students to do their best while playing the game, two $50 rewards were offered for players with the highest scores. All participants played the DSG through the Second Life interface. Participants in the individual setting were asked to think aloud while playing whereas those in the collaborative setting communicated with each other through a microphone via VoIP (voice over Internet Protocol). Participants in the collaborative setting never saw each other and all their interaction took place through Second Life following a collaborative script that included several elements recommended by the
cooperative learning literature such as positive interdependence, individual accountability, and group monitoring.

After playing the game for 80 minutes, all participants took a post-test and completed a questionnaire related to their attitudes and reactions towards their learning experience using the DSG as well as their level of satisfaction having played the game in an individual or a collaborative setting.

A method of observational research called Analysis of Patterns in Time (APT) that aims at exploring patterns of transactions among students, teachers, curricula, and educational settings (Frick, 1990) was used by the researcher to investigate the differences of patterns of game play strategies used between the players with the highest game scores versus those with the lowest scores.

Research Questions and Hypotheses

Specifically, the study sought to answer the following three research questions:

Research Question 1

Are there any differences in game performance, learning, and attitudes among learners playing an online instructional game individually versus playing it in dyads while following a collaborative script?

Based on the literature related to cooperative learning, which includes hundreds of studies comparing individual versus cooperative learning across multiple disciplines (Johnson et al., 1991; Johnson et al., 1998a; Johnson et al., 1998b; Slavin, 1995; Springer et al., 1999), the following hypothesis to this question was posited:

Hypothesis 1: Participants in the collaborative setting will outperform participants in the individual setting in terms of game scores and gains in learning.
Research Question 2

How do personality traits correspond with performance, learning, and attitude in students playing an online instructional game in both settings (individually and collaboratively)?

This research question examined the relationship between the personality traits and participants’ performance and attitudes. Even though the relationship between specific personality traits and task performance is in function of the nature of the task (Driskell et al., 1987, Kichuk & Wiesner, 1997), several studies have reported that conscientiousness seems to be related to task performance (Bell, 2007; Kichuk & Wiesner, 1997). As explained previously, conscientiousness refers to the level of responsibility, reliability, and perseverance of an individual (Barrick & Mount; 1991).

Based on these findings, the following hypothesis was put forward:

_Hypothesis 2: Conscientiousness will be related to the game performance in the individual setting._

Proposing a similar hypothesis for the collaborative setting was not possible due to the limited number of dyads of participants and also because the dyad assignment was not controlling for the level of conscientiousness thus dyads could be composed of participants with very disparate levels of conscientiousness.

In addition to the level of conscientiousness, some studies have reported the levels of agreeableness and extraversion to be be related to performance in tasks conducted within teams (Bell, 2007; Kichuk & Wiesner, 1997). Agreeableness refers to concepts such as trust, tolerance, confidence, and willingness to cooperate. Agreeableness and extraversion are the only two personality traits that are intrinsically interpersonal (Koole
et al., 2001). In the present study, the dyad assignment was controlled based on homogeneous levels of agreeableness, thus the following hypothesis was posited:

_Hypothesis 3: Agreeableness will be related to the game performance in the collaborative setting._

According to personality psychology, extraversion refers to the extent to which a person enjoys socializing with others (Barrick & Mount; 1991). In contrast, those with a low level of extraversion tend to be more reserved, introvert, and have a preference towards working alone. The following hypothesis was thus posited:

_Hypothesis 4: Participants’ attitudes towards having played in the setting assigned will be correlated to their level of extraversion: extroverts will express their preference for continuing to play collaboratively while introverts will prefer playing individually._

**Research Question 3**

What are the main pattern differences between the games with the highest and lowest scores? Are there any common patterns in the game play strategies used by students within each setting (individual or collaborative)??

The last research question was aimed at exploring the common patterns of strategies used in the games played by participants with the highest and lowest scores. Myers (2012) identified nine strategies that, being aligned with the diffusion of innovations theory, are effective for obtaining a high score in the DSG. He used a computer program that automatically played 500 times an updated version of the original DSG. For each turn in a game, the program analyzed the game state and implemented the most appropriate of the nine strategies. This approach resulted in more than 60% of the
games achieving at least 166 out of 220 possible adoption points, which he considered sufficient to verify the accuracy of the DSG's computational model with respect to diffusion of innovations theory. Based on these findings, the following hypothesis was stated:

_Hypothesis 5: Games with the highest scores will use strategies that are aligned with the diffusion of innovations theory more often than games with the lowest scores._

A critical difference observed between high and low performing computer game players is their depth of thinking (Hong & Liu, 2003). While low performing players rely mainly on trial-and-error techniques that involves tasks such as selecting and testing, Hong and Liu (2003) state that high performing players use a more strategic thinking, which involves tasks such as selecting, testing, classifying, comparing, analyzing, and judging. Since the game used in this study requires the application of analytical and cognitive processes such as inferring, evaluating, comparing, and judging, the following hypothesis was also put forward:

_Hypothesis 6: Game performance will be related to the total number of turns that were played using strategic thinking and cognitive processes._

Moreover, in studies regarding team performance, the degree of participation within a group has been reported as being correlated to the performance of the tasks (Montoya, Massey, & Lockwood, 2011; Williams & Sternberg, 1988). In those studies, the degree of participation was operationalized as the total amount of written or verbal communication done by all members of the group. The assumption in those studies was that the higher the degree of participation, the more exchange of ideas and sharing of information there would be. Following a similar logic, the next hypothesis was proposed:
Hypothesis 7: In the collaborative setting, game performance will be related to the dyads’ degree of participation, exchanges of ideas, and sharing of information.

Study Significance

The present study is intended to add to the body of knowledge in the fields of CSCL and game-based learning about the potential effects that personality traits might have when playing a particular instance of a synchronous online game in which the communication among players is done verbally. Most current studies in CSCL focus mainly on the use of text-based communication such as online forums and chats. Moreover, studies exploring the relationship between personality traits and team collaboration have been conducted in onsite settings.

The study might help determine whether it is worth investing the time and effort in having all students within a class playing a particular online game collaboratively or if the students’ personality traits and personal preferences should influence the setting that an instructor chooses (whether individually or collaboratively).

The study might also help in identifying potential ways in which a 3D virtual world could be used to play instructional simulation games in a collaborative way as well as providing some suggestions regarding the general patterns in the interaction between players that seem to be more effective for succeeding in the game.

Organization of Following Chapters

This study is organized into five chapters. This first chapter has provided an overview of the context of the study, its purpose and significance. Chapter two includes a review of the literature regarding the different disciplines involved in the study: cooperative and collaborative learning, personality psychology, computer-supported
collaborative learning, and game-based learning; the chapter then concludes with a review of similar studies and an explanation of how they differ from this study. Chapter three describes the methods used providing an ample description of the Diffusion Simulation Game and its integration with Second Life, the steps taken to recruit participants as well as a detailed explanation of the procedures implemented for conducting the study. Chapter four provides the results obtained from the analyses of the data collected from all instruments used in this study such as the pre-test, game sessions, post-test, and reactionnaires. Chapter five provides a discussion of the results while addressing each of the research questions that prompted this study. Additional content in this last chapter include the study limitations as well as further research suggestions.
CHAPTER II: REVIEW OF LITERATURE

This chapter includes a review of the existing literature relevant to the multiple disciplines involved in the study (cooperative and collaborative learning, personality psychology, Computer-Supported Collaborative Learning, and Game-based learning). The chapter concludes with a review of similar studies and an explanation of how they differ from the study being conducted.

Cooperative and Collaborative Learning

As social beings, we depend upon the interaction between each other to augment our general cognition and knowledge. Indeed, it is practically impossible to fully achieve certain knowledge and skills, such as language development, in isolation (Rogers, 1996). Since Ancient Greece, social interactive instructional strategies like dialectics have been advocated as part of a formal education (Rud, 1997). More recently, several theorists’ observations have suggested that the social environment and peer interaction have a significant impact on children’s development (Dewey, 1916; Montessori, 1964; Piaget, 1952; Vygotsky, 1978).

By interacting with peers, people are able to externalize their thoughts, negotiate meaning, have their beliefs challenged and enter in a state of disequilibrium (Piaget, 1952), move beyond the Zone of Proximal Development (Vygotsky, 1978) and complement each other’s strengths and limitations (Bruffee, 1999). Kagan (1994) identified several positive outcomes when working within a team such as (1) academic gains, especially for low achieving students and minorities, (2) improved race-relations among students and (3) improved social and affective development.
Hundreds of studies across all ages, academic levels, and within a great variety of subject areas have demonstrated that learning is more effective when students work cooperatively than when they work individually (Brush, 2007; Chang & Mao, 1999; Klein et al., 1999; Johnson et al., 1991; Johnson et al., 1998; Jonassen et al., 2001; Lehtinen et al., 2001; Lou et al., 2001; Mergendoller et al., 2000; Slavin, 1995; Springer et al., 1999). In a meta-analysis of cooperative learning methods, Johnson, Johnson and Stanne (2000) state that there are over 900 research studies that validate the effectiveness of cooperative efforts over both competitive and individualistic ones.

Some authors distinguish between two approaches in which team members can interact when working on a learning activity: cooperative and collaborative learning. The main difference between both of them relies on the extent to which the interaction among members is structured. Johnson, Johnson and Smith (1998) refer to cooperative learning as the heart of problem based-learning and define it as working together in structured groups to accomplish shared learning goals. On the other hand, Roschelle and Teasley (1995) define collaboration as “the mutual engagement of participants in a coordinated effort to solve the problem together” (p. 70).

In both collaborative and cooperative learning, students work together in a coordinated way to achieve a shared goal. In a “natural collaborative” setting, the coordination process emerges from the students themselves whereas in a cooperative setting, this process is imposed by a person external to the team, usually the instructor. In a cooperative setting, for instance, the instructor could split the learning task in several subtasks and assign these subtasks to the team members; each member would then work individually in his/her subtask. In a collaborative setting, the instructor would just assign
the whole task to the team and all team members would work on the complete task without splitting it. In spite of the distinction between the terms “cooperative learning” and “collaborative learning”, they have been used interchangeably in the literature (Dillenbourg et al., 1996; Kitchen & McDougall, 1998; Wessner & Pfister, 2007). In a realistic setting, these terms are complementary, “there is no formal threshold that would discriminate cooperation from collaboration” (Dillenbourg, 2002).

Regardless of the approach selected for teamwork, whether it is collaborative or cooperative, several studies have identified specific factors that might a) facilitate the interaction among team members, b) balance the amount of load of work among team members and c) promote both team and individual gains in performance and achievement. Some of these factors are: positive interdependence, learning task nature, group processing, social skills, group size (Johnson, Johnson & Holubec, 1994), individual accountability, team rewards, equal opportunity for success, group composition (Slavin, 1995), affiliation motive (Klein & Schnackenberg, 2000), and mutual trust (Brown, Poole, & Rodgers, 2000; Spencer, 2001).

Positive interdependence: Team members need to realize that the only way to succeed as a team is by the joint effort and success of each of them (Johnson, Johnson & Holubec, 1994). This is the most important factor of any cooperative learning task. Each member can be held individually accountable for the work of the entire team, and the team as a whole is responsible for the learning of each individual member (Kirschner et al., 2005). Johnson and Johnson (1991) identify the following types of positive interdependence:
a) Positive goal interdependence: There is a mutual goal or a set of goals that the team has to achieve and each team member recognizes that the only way to achieve the team goal is by attaining their individual goals.

b) Positive reward interdependence: There is a joint reward for successful teamwork.

c) Positive resource interdependence: The resources or information necessary to complete the learning task is distributed among team members and they have to combine these resources in order to achieve the goal.

d) Positive role interdependence: Each team member is assigned a specific role that specifies the responsibilities needed to complete the team task.

e) Positive identity interdependence: There is a mutual identity among the team members such as a logo, a motto, etc.

f) Environmental interdependence: Environmental constraints force team members to work together, such as an assigned meeting area (Brush, 1998).

Learning task nature: Some learning tasks are more conducive to benefit students when working individually than working collaboratively (Kumpulainen & Kaartinen, 2004) such as tasks that require drill and practice and rote learning. On the other hand, collaboration is more appropriate for epistemic tasks that require meaning negotiation, explanation, evaluation, or prediction.

Group processing: To maximize their own and each other’s learning, team members must take the time to identify as a group ways in which to improve their team work. Group processing could be achieved by having team members a) identify helpful
actions to ensure effective working relationships and b) make decisions about what behaviors to keep or to change (Johnson et al., 1998).

**Personality Traits**

Just as some learning tasks are more conducive to collaboration than others, likewise, certain students would benefit more from working collaborative than working individually (Johnson & Johnson, 1989; Klein & Schnackenberg, 2000). According to several studies, personality traits might influence the performance of individuals when working within a team (Hall et al., 1988; Jones et al., 1996; Klein & Schnackenberg, 2000).

Personality traits are relatively permanent characteristics of individuals (Helmreich, 1984), are mostly inherited and are not easily changed by interventions such as behavioral training (Kichuk & Wiesner, 1997). Psychology researchers have found five factors that fit the structure of personality; these factors are called The Big Five and include: Agreeableness, Conscientiousness, Extraversion, Emotional Stability, and Openness to Experience or Culture.

Barrick and Mount (1991) describe the personality traits as follows: Agreeableness refers to concepts such as trusting, politeness, tolerance, and willingness to cooperate. Extraversion refers to the level of sociability, gregariousness and assertiveness of individuals. Conscientiousness refers to the level of responsibility and reliability of an individual and it is also associated with concepts such as endurance or perseverance. Neuroticism also known as emotional stability refers to the level of anxiety, depression, and insecurity of an individual. Openness to new experiences refers to the level of curiosity, creativity and broad-mindedness of an individual.
Several self-response instruments intended to measure personality traits have been developed within the past 50 years. Most of these instruments measure different levels of The Big Five. Some of these instruments are the Revised NEO Personality Inventory (NEO-PI-R), the Big Five Inventory, the Work Motivation Inventory, the Eysenck Personality Questionnaire, and the Personality Research Form.

The NEO-PI-R is the most recommended instrument to measure the prototypical components of the Big Five (Costa & McCrae, 1985); it includes 240 items and measures the following facets from The Big Five core attributes:

<table>
<thead>
<tr>
<th>Neuroticism</th>
<th>Extraversion</th>
<th>Openness to experience</th>
<th>Agreeableness</th>
<th>Conscientiousness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anxiety</td>
<td>Warmth</td>
<td>Fantasy</td>
<td>Trust</td>
<td>Competence</td>
</tr>
<tr>
<td>Hostility</td>
<td>Gregariousness</td>
<td>Aesthetics</td>
<td>Straightforwardness</td>
<td>Order</td>
</tr>
<tr>
<td>Depression</td>
<td>Assertiveness</td>
<td>Feelings</td>
<td>Altruism</td>
<td>Dutifulness</td>
</tr>
<tr>
<td>Self-Consciousness</td>
<td>Activity</td>
<td>Actions</td>
<td>Compliance</td>
<td>Achievement</td>
</tr>
<tr>
<td>Impulsiveness</td>
<td>Excitement</td>
<td>Ideas</td>
<td>Modesty</td>
<td>Striving</td>
</tr>
<tr>
<td>Vulnerability to Stress</td>
<td>Seeking positive emotion</td>
<td>Values</td>
<td>Tender-mindedness</td>
<td>Deliberation</td>
</tr>
</tbody>
</table>

The Big Five Inventory (BFI) is a shorter alternative to the NEO-PI-R. It includes 44 self-response items that use a 5-point Likert scale. The items were selected using factor analysis in large samples of junior college and public university students (John et al., 2008). The items are written as short phrases based on the trait adjectives that are
prototypical markers of the Big Five (John, 1990), such as: “I am someone who is sometimes shy, inhibited” or “I am someone who generates a lot of enthusiasm.”

The BFI measures five scales, each of them associated with a factor of the Big Five. Each scale contains eight to ten items without sacrificing psychometric properties or content coverage. For instance, the Agreeableness scale contains nine items and most of them are related to at least five of the six facets suggested by the Big Five Model, specifically trust, altruism, compliance, modesty and tender-mindedness (John et al., 2008).

Using a sample of 829 undergraduate students, John et al. (2008) compared the reliability of the BFI to other personality instruments such as the NEO-PI-R, the NEO-FFI and the TDA and found that the coefficient alpha reliabilities were relatively similar in size across instruments, with a mean alpha of .83 for the BFI. Based on these results, John et al. suggest using the BFI when participants’ time is a premium and the investigation calls for measuring the core attributes of the Big Five instead of their multiple facets.

The Work Motivation Inventory (WMI) measures the importance an individual places on four factors: (1) accomplishment, (2) recognition, (3) power, and (4) affiliation (Maehr & Braskamp, 1986). The WMI is a 77-item inventory, which has been found to be highly correlated to work motivation, to predicting job success, and in understanding burnout and stress (McAlhaney, 2006). The following table includes an interpretation of the WMI’s affiliation factor:
Table 2.2  
\textit{WMI's affiliation factor interpretation}

<table>
<thead>
<tr>
<th>Scores below 50:</th>
<th>Scores above 50:</th>
</tr>
</thead>
<tbody>
<tr>
<td>People who score in the lower range generally place relatively little importance on having close personal relationships and support networks.</td>
<td>People who score in the higher range on this scale enjoy the company of friends and like to be around other people.</td>
</tr>
<tr>
<td>They usually prefer to work alone rather than as part of a team.</td>
<td>As a result, they are very sensitive to the needs of others and place high value on the quality of their relationships with others.</td>
</tr>
<tr>
<td>They identify with self-sufficient or reserved people who avoid close personal contacts.</td>
<td>They don’t work at their best or for long periods of time alone.</td>
</tr>
<tr>
<td>On occasion they may be viewed as uncaring or unfeeling.</td>
<td>They generally trust people and are able to relate warmly to them.</td>
</tr>
<tr>
<td>Because they do not always understand others well, others may not always understand them.</td>
<td>Individuals who score high can frequently be counted on to sacrifice personal gain for others. (Maehr &amp; Braskamp, 1986).</td>
</tr>
</tbody>
</table>

The Personality Research Form (PRF) is an extensively researched instrument of normal personality. It provides scores for personality traits relevant to the functioning of individuals in a wide variety of situations. The PRF is composed of 352 true-false items and requires about 45 minutes to complete (Pantesting, 2011). The PRF measures the following dimensions: abasement, achievement, affiliation, aggression, autonomy, change, cognitive structure, dependence, dominance, endurance, exhibition, harm, avoidance, impulsivity, nurturance, order, play, sentience, social recognition, succorance, understanding, infrequency, and desirability.

As evidenced by the instruments discussed above, most instruments designed to measure personality traits include a dimension that is similar to Agreeableness. Even though the labels and the exact definitions vary across different instruments, all theorists
seem to recognize the importance of this dimension (John et al., 2008; Koole et al., 2001).

**Computer-Supported Collaborative Learning**

The field of Computers-Supported Collaborative Learning (CSCL) is concerned with studying how people can learn together with the help of computers (Stahl et al., 2006). The field emerged in the 1990’s as educational institutions started using Local Area Networks. Research and literature in the CSCL field have proliferated with the advent of the Internet, and more specifically with the significant growth of online courses.

Key theories that have contributed to CSLC theory include: cooperative learning theory (Johnson et al., 1995; Slavin, 1997), Computer-Supported Collaborative Work (CSCW) (Lehtinen et al., 1999), and Computer-Mediated Communication (CMC) theory (Harasim, 1991; Koschmann et al., 1994; Mayes et al., 1995; Wang, 2009). Cooperative learning theory has already been described above.

CSCW aims at providing higher levels of coordination and cooperation among employees within an organization through information technology systems; these systems facilitate the process of (1) sharing, accessing and organizing the information and (2) communicating with other individuals within the organization via applications such as videoconferencing, instant messaging, or email (Lehtinen et al., 1999).

CMC refers to the “communication that takes place between human beings via the instrumentality of computers” (Herring, 1996, p.1). This field emerged to study the impact of the differences between face-to-face communication and the interaction that takes place within computer networks such as time delay (Jeong & Frazier, 2008;
Howard, 2012), potential anonymity (Chester & Gwynne, 1998; Howard, Barrett, & Frick, 2010) and lack of complete sensory cues (Daft & Lengel, 1984). Most of the existing CMC studies have been conducted in text-based environments either synchronously or asynchronously. The main reason for the abundance of text-based studies is that historically there have been more text-based communication modes than any other modes. In this regard, Herring (2002) identifies the following modes in order of their mainstream acceptance in popular use: e-mail, listserv discussion lists, Usenet Newgroups, split-screen protocols, chat, Multi-User Dimensions (MUDs), Audio and Video, and Virtual Reality environments.

Collaborative Scripts

In an effective collaborative learning task, all team members participate equally and each of them benefit by learning from each other and from the global collaborative experience. However, having students working together in an unstructured way does not necessarily imply that they will be working collaboratively. Some students might invest less effort or no effort at all to accomplish the team task, issue known as the free-riding or hitch-hiking effect (Kirschner, 2002). In other situations students might take a competitive approach instead of a collaborative one. In order to minimize potential negative issues in the collaboration process, the implementation of collaborative scripts are recommended.

A collaborative script is a set of instructions that describe how the group members should interact, collaborate and solve the problem (O’Donnell & Dansereau, 1992). Dillenbourg (2002) identifies five attributes of collaborative scripts: task definition, group composition, task distribution, mode of social interaction and timing.
**Task definition** refers to the task that group members have to perform. It is important to consider that some tasks are more conducive to collaborative environments than others. In general, tasks that involve lower-order thinking skills in Bloom’s taxonomy such as rote learning or solution of problems with just one correct answer are inappropriate for collaborative approaches since they tend to lead to mechanistic and product-oriented interactions (Kumpulainen & Kaartinen, 2004). On the other hand, collaboration might be more appropriate for solving open-ended tasks and ill-structured problems that require using higher-order thinking skills (analysis, evaluation and synthesis). Group members might benefit from joining efforts and combining their critical and creative thinking to solve the task.

**Group composition** refers to the number of individuals within the group and the criterion for group formation. Depending on the task, the group size for collaborative groups might vary from small groups (having two to four members) to a whole class or even a set of classes. However, previous studies in face-to-face contexts have concluded that small teams of up to four members often collaborate more effectively than larger teams. The criterion for group formation can be based on heterogeneity or homogeneity of certain attributes among team members such as level of expertise, domain of expertise, friendship, or geographical and cultural background (Dillenbourg, 2002). Lehtinen et al. (1999) suggest that team heterogeneity in terms of cognition and expertise promotes knowledge advancement and cognitive growth among all team members.

**Task distribution** is defined as the way the global collaborative process is distributed among the group members. The most common method of task distribution is role assignment. Members can have roles such as reader, recorder, encourager of
participation, and checker for understanding (Johnson, Johnson & Johnson, 1994b). In addition, role assignment provides a way to ensure positive interdependence among group members, bringing positive effects on participation interaction and achievement (Klein & Doran, 1999). Alternatively, roles can be switched among members during the collaboration process for all of them to encourage equal participation.

*Mode of social interaction* refers to the type of communication among group members, whether face-to-face or online, and whether synchronous or asynchronous. This attribute also specifies a) whether the interactions will be taking place one-to-one, one-to-many or many-to-many, b) the type of communication media to be used (textual, audio, video, etc.), and c) if and how the instructor will be interacting with the group members.

*Timing* refers to the duration of the collaboration process. In regards to timing, Johnson et al. (1994) classify the learning groups as: a) informal cooperative groups lasting from a few minutes to one class period, b) formal cooperative learning groups lasting from one class period to several weeks, and c) cooperative base groups lasting for at least a year.

**Game-Based Learning**

Digital games can be classified as entertainment games, which are mainly designed for leisure, and as serious games, which are designed primarily for instructional purposes, beyond entertainment (Meyer & Sørensen, 2007). As with any game, serious games rely on an underlying principle of play represented by a sense of contest or challenge between a player and the system or among players.
Well-designed instructional games incorporate learning and pedagogical strategies to assist in the learning transfer process. Becker (2007) argues that “good games already possess the major components necessary of sound instruction” (p. 26); she then examines games major components and compare it to well-known instructional theories such as Gagné’s Nine Events of Instruction (Gagné, Briggs, & Wager, 1992), Reigeluth’s Elaboration Theory (Reigeluth, Merrill, Wilson, & Spiller, 1980) and Merrill’s First Principles of Instruction (Merrill, 2002).

Studies conducted on digital games and simulations in diverse fields have demonstrated their effectiveness in promoting learning (Aldrich, 2005). According to Kirriemuir and McFarlane (2004) there are two main reasons for using instructional games: (1) their power to engage and motivate, and (2) their ability to facilitate learning through doing. Garris et al. (2002) suggests that educators should be interested in using games in instruction because of the intensity of involvement and engagement they provide and also because they facilitate the shift to a learner-centered model. Game playing is also associated with the promotion of creativity and the development of critical thinking and problem-solving skills.

When analyzing the use of digital games for instructional purposes, several studies have highlighted the motivational and social benefits. Malone (1981) identifies several factors that make an activity intrinsically motivating: challenge, curiosity, control, and fantasy. Indeed, all of these factors are inherent in almost any good digital game and contribute, in combination, to maintaining the player in a state of flow experience, which, according to Csikszentmihalyi (1997) represents a total immersion and absorption of an individual when playing a game.
Digital simulations provide an environment that mimics a real scenario thus facilitating learning in those situations that are too expensive or dangerous to conduct in real life. Bonk and Zhang (2008) mention that simulations can find use in almost any discipline and that they “not only require the learner to employ facts and information learned, but require strategic thinking and problem solving” (p. 1840).

Simulation games exhibit the basic characteristics of both simulations and games. As a simulation, they allow players to participate in activities that are difficult or even impossible to do with traditional materials (Shaffer, 2006). Reigeluth and Schwartz (1989) identify three major aspects of simulations: (1) the scenario, which mimics a real life situation including objects, persons, and places; (2) the model, represented by the rules and mechanics of the user interaction with the simulated environment; and (3) the instructional overlay, represented by strategies to optimize learning and motivation. Moreover, simulations provide players with opportunities to practice a specific activity in a digital environment.

**Related Studies**

Using a problem-solving mathematical task, Sears (2013) compared the performance of 110 seventh grade students working individually or in dyads. Forty-one of these students were part of an accelerated math class while the others were part of a traditional math class. All students took a pre-test and then they worked either individually or in dyads for 15 minutes on the problem-solving task. The pre-test results were correlated with the students’ performance in this task. Students from the traditional class found the task more difficult than those in the accelerated class. The results of the study indicated that students from the accelerated math class working individually
performed significantly better than those working in pairs, whereas students from the traditional class working in pairs outperformed those working individually.

Mullins, Rummel, and Spada (2011) examined differential effects of collaboration on student’s computer-supported learning using mathematical story problems. The study compared the performance of four groups composed of 20 high school students each. Half of the groups worked individually while the other half worked in dyads. A group working individually and a group working in dyads received conceptual instruction about the story problems whereas the remaining two groups received procedural instruction. All students took a pre-test that included both conceptual and procedural problems. Students then used a computer to solve the story problems, either individually or in dyads. Finally, each student took a post-test. The authors stated that “in both the conceptual and the procedural conditions, students who worked in a collaborative setting showed better performance during the learning phase than students who solved problems individually” (p. 432).

As part of the above study, Mullins, Rummel, and Spada (2011) used a coding schema to analyze think aloud protocols of students working individually and the dialogue of the students working in dyads. They focus their analysis on the students’ behavior right after making an error. One of the aspects included in this analysis was elaboration process after errors, which consisted of three codes: elaboration, used when students elaborated on the error attempting to correct it; no elaboration, used when students corrected the error after remaining silent for a while; and immediately corrected, used when students immediately corrected the error without providing any explanation. Based on this analysis, the authors concluded that “collaboration is particularly beneficial
for knowledge acquisition in mathematics if the learning material does not so much emphasize stepwise problem-solving, but requires elaborative learning activities and thus benefits from mutual explanations and joint discussions” (p. 438).

Klein and Schnackenberg (2000) conducted a study that compared the performance of 122 undergraduate education majors working individually versus working cooperatively. Jackson’s (1974) Personality Research Form-E was used to measure the level of affiliation of each participant. Affiliation is a dimension of the level of extraversion and refers to the extent in which an individual is capable and willing to interact and communicate with others. The instructional materials included a 30-minute video lesson and a workbook questionnaire. Participants worked physically together in dyads with a partner who had a similar affiliation motive. Results indicated that participants who worked individually performed better and had more continuing motivation for working alone than dyads working cooperatively.

Collazos, Guerrero, Pino, Ochoa, & Stahl (2007) used a digital game to investigate ways to promote computer-based collaboration. They conducted a study involving eleven groups of four randomly selected students. Students were physically apart from each other while playing a game that consisted of solving a four-quadrant labyrinth during 45 minutes. Each player was able to see the quadrants from the other three players but not his/her own quadrant. Players thus relied on the assistance from the other players to be able to solve their own quadrant. The communication among players was done via a text-based chat tool. The study included three types of positive interdependence: (1) goal interdependence since all four individual quadrants had to be solved in order to traverse successfully the labyrinth; (2) resource interdependence since
each player had two roles, as coordinators they would work on their own quadrant and as collaborators they would help others to solve their quadrants; and (3) reward interdependence given by trying to maintain the highest score which decreases every time players made a mistake (e.g. hitting an obstacle when trying to solve their quadrant.)

Based on the content analysis of all the messages sent among the players, Collazos et al. (2007) proposed a model for supporting collaboration. The model consists of the following steps: (1) establishing initial conditions such as type of activity, positive interdependences, conditions, nature and period of collaboration, and group heterogeneity; (2) structuring collaboration by helping participants to identify the goals and rules of each task in the collaboration process, assigning appropriate roles to each participant and providing the right tools and objects to enable the communication and coordination among participants; and (3) maintaining the collaboration among members of the group by providing, for instance, a cognitive mediator who encourages frequent reflection and guarantees that all team members participate in the process.

Within the military context, the Defense Advanced Research Projects Agency of the Department of Defense explored ways to improve Shared Situational Awareness (SSA) using a collaborative game called “SCUDHunt”. In this digital game, a team of four players physically apart from each other must collaborate to locate three SCUD missile launchers that are hidden on a 5x5 game board. Each player has an assigned role which allows them to collect different kind of information. A set of studies were conducted by ThoughtLink Inc. from 2000 to 2002 with the goal to determine what type of communication technologies were more likely to increase SSA.
The communication technologies analyzed were verbal communication via phone, a text chat, and a shared visualization tool. However, no statistically significant differences among the diverse technologies were found (Stahl, 2002).

Several studies have investigated collaborative learning using digital games (Steinkuehler, 2006; Taylor & Jakobsson, 2003). However, the goal of most of these studies has been to explore the level of collaboration within the team members without measuring the learning acquired as a result of the collaboration process. Moreover, most of these studies have been done using text-based communication such as a chat interfaces.

Montoya, Massey, and Lockwood (2011) explored the link between collaborative behaviors and virtual team performance in Second Life, a three-dimensional (3D) virtual world. There were 91 participants working in pairs or in groups of three. Their task was to solve as many 3D puzzles, composed of nine cubes, as possible within 20 minutes. Participants interacted with each other through a chat interface. As an incentive, they were informed that those participating in the best performing team would receive $100 each. To measure collaborative behavior, the researchers used the total number of words that the members typed in the chat interface. Team performance was measured by the total number of puzzles solved as well as by the mean time used to solve them. Their results indicated that “higher performing teams perceived that they were better able to coordinate their teamwork by developing clear strategies and reaching consensus as compared to lower-performing teams” (p. 465) and that “less equitable contribution was related to lower team performance” (p. 466).
Johnson, Wyeth, Sweetser, and Gardner (2012) examined the relationships between personality traits, gaming experience, and videogame preference. Their study included 466 participants. The majority of them (74%) were college students enrolled in a videogame course. Two instruments were used to measure the personality traits based on the Big Five Model: the first half of the participants used the ten-item personality inventory (TIPI) and the second half used John’s et al. (2008) Big Five Inventory (BFI). All participants also submitted IJsselsteijn, de Kort, and Poels (in prep.) Game Experience Questionnaire (GEQ), which measures game competence, sensory and imaginative immersion, flow, tension/annoyance, challenge, negative affect, and positive affect. The study results indicated that “Conscientiousness was found to be correlated with challenge ($r = 0.10$), competence ($r = 0.10$), annoyance ($r = -0.17$) and flow ($r = -0.22$) such that people with higher levels of conscientiousness were more likely to report higher levels of challenge and competence when recalling their experience with the current favourite game and lower levels of annoyance and flow” (p. 119).

Duckworth, Peterson, Matthews, and Kelly (2007) investigated the relationship between Conscientiousness and grit. They defined grit as “perseverance and passion for long-term goals” (p. 1087). The grit scale they developed contains 12 items. Examples of these items are “I finish whatever I begin” and “Setbacks don’t discourage me”. In one of the studies they conducted, 706 participants completed John’s et al. (2008) Big Five Inventory (BFI) and also the 12-item grit scale. As the authors hypothesized, grit was highly related to Conscientiousness ($r = .77$, $p < .001$). According to the authors, while conscientious and gritty individuals are both achievement-oriented the former have more emphasis in a short-term goal whereas the latter have more emphasis on long-term
stamina. Results from other studies indicated that grit was not related to IQ, (meaning that persistence, diligence, and determination could be better predictors than is IQ of long-term success) and that “grit may be as essential as talent to high accomplishment” (p. 1100).

**Summary**

This chapter has provided a general review of the existing literature concerning the different areas involved in this study, including cooperative and collaborative learning, personality traits, computer-supported collaborative learning, and game-based learning. The chapter also provided the description of ten studies that have examined the relationship between at least two of these different areas. For instance, some of these studies investigated the relationship between cooperation and computer-supported collaborative learning (Collazos et al., 2007; Montoya, Massey, & Lockwood, 2011; Mullins, Rummel, & Spada, 2011) and others investigated the relationship between personality traits and performance (Klein & Schnackenberg, 2000; Johnson, Wyeth, Sweetser, & Gardner, 2012).

Some of these related studies have been included in this chapter because their findings differ from those presented by the overall existing literature related to cooperative learning. The results of these studies indicate that in some cases, when people work individually tend to perform significantly better and obtain greater gains in learning than when working collaboratively (Klein & Schnackenberg, 2000; Sears, 2013). These diverging results prompt for further investigation comparing individual versus collaborative performance.
CHAPTER III: METHODS

This study explored the impact of implementing a collaborative instructional strategy when playing an online educational simulation game, the relationship between players’ performance and their personality traits, and the level of satisfaction and perceptions of players using the game as instructional material to learn about the diffusion of innovations theory.

A pre-test/post-test control group quasi-experimental design was implemented to address the research questions that guided this study. The independent variable was the type of setting in which participants played an educational game, either individually or collaboratively. The dependent variables were knowledge acquisition, game performance, and attitudes towards having played in the setting assigned.

This chapter describes the educational game used in this study, the participant recruitment process, the methods and procedures implemented, the diverse instruments and data sources used, as well as the data analysis conducted.

The Educational Game Instance: The Diffusion Simulation Game

This study utilized a modified version of an online game called the “Diffusion Simulation Game” (DSG) as instructional material. The DSG, which teaches change management strategies aligned with the diffusion of innovations theory as described by Rogers (2003), was originally designed as a board game at the Indiana University School of Education in 1976. It was part of a full-day workshop on diffusion strategies and had as a goal to provide classroom teachers with skills to disseminate instructional materials developed by them (Molenda & Rice, 1979).
In the DSG, the player is assigned the role of a newly hired teacher in a junior high school. The player’s mission is to act as a change agent by persuading up to 22 staff members to adopt peer-tutoring as an instructional innovation in their classrooms. The player has to conduct several information and diffusion activities (such as demonstrations, site visits, pilot tests, and workshops) in order to influence staff members on their path to adopt the innovation.

Molenda and Rice (1979) identified the following ten DSG learning objectives:

1. Classify persons as to adopter type (i.e., innovator, early adopter, early and late majority, and resister) on the basis of observable characteristics (e.g., education, cosmopolitanism, life-style, and the like).
2. Identify and name the psychological phases leading to the decision to adopt or reject an innovation (i.e., awareness, interest, appraisal, and trial).
3. Identify key individuals according to their communication roles (e.g., format leaders, opinion leaders, gatekeepers, and so on).
4. Recognize that informal social groupings may be more indicative of similar values and influence patterns than formal groupings or positions.
5. Value the importance of having an overall plan before initiating a diffusion campaign.
6. Select a diffusion strategy which strikes a balance between information-gathering and active dissemination efforts.
7. Name and define a variety of alternative diffusion activities such as face-to-face conversation, presentations at meetings, site visits, printed communications, in-service workshops, and demonstrations.
8. Match various diffusion activities with different phases of the adoption process in which they would be most effective.

9. Recognize that innovation diffusion is a complex, difficult, time consuming, and often frustrating process (since even well-planned campaigns may result in less than total acceptance).

10. Enjoy the learning experience and feel that the time invested in it was worthwhile. (p. 461).

This Study’s Diffusion Simulation Game Version

The original DSG board game version was played in teams of three to four students in a Change Management course in the Instructional Systems Technology (IST) department at Indiana University. With the opening of a distance program and the consequent offering of this course in the online environment, a first digital version was developed as similar as possible to the board version (Frick, Ludwig, Kim, & Huang, 2003).

After two pilot studies using the first DSG digital version, the researcher decided to develop a new version for this study for the following reasons:

1) The original DSG digital version does not provide multiplayer functionality. It was mainly designed to be played individually. The implementation of alternatives such as screen sharing or establishing a remote connection did not work properly because in these alternatives one player must have the full control of the interface at a time. This could have potentially hindered the collaboration process when playing the game.

2) The amount of time required to play the original DSG digital version individually for the first time was an hour on average. Playing it collaboratively increased
the time to an hour and fifteen minutes. Time was a concern due to the potential of the participants’ mental fatigue, which could have affected the post-test results after playing the game several times.

3) The outcomes of conducting an activity in the original DSG digital version are highly stochastic mainly due to the fact that one of the goals of the original game was to recognize the complexity and non-deterministic nature of the process for diffusing an innovation. This was a concern because since participants would play the game for less than two hours, they might have not had enough time to identify effective strategies as recommended by the diffusion of innovations theory. Lara, Enfield, Myers, and Frick (2010) conducted a study involving four participants who played the original DSG version three times for about two hours and a half. Partly due to the great variety of possible outcomes, none of the players was able to identify all strategies aligned with the diffusion of innovations theory that are effective for winning the game.

For the above reasons, the researcher developed a new multiplayer online DSG version, which could be played within a three-dimensional virtual world called Second Life. In this new version, the number of staff members in the game was reduced by half, from twenty-four to twelve. The number of diffusion activities was reduced from thirteen to seven. Moreover, the outcomes of conducting an activity were adjusted to be less stochastic with the goal of facilitating the identification of the appropriate selection of activities. For instance, while conducting some activities in the original DSG version players might have up to four different outcomes (the activity could be not effective at all, barely effective, effective or extremely effective) whereas in this study there are just two outcomes (the activity is either effective or ineffective).
An additional change to the original DSG version was in the way the directions and mechanics to play the game were presented. In the original version, the directions of the game are outlined on five web pages that explain the resources available, the mechanics of the game, and the process used to conduct the first moves. To avoid cognitively overloading players before starting the game, the mechanics and rules were provided in a contextualized way, as the game was played. To start the game, players were presented with the case scenario shown in Figure 3.1.

![Figure 3.1. Login screen of the DSG version used in this study](image)

The DSG interface is shown in Figure 3.2. In the left-hand side there are the lists of information and diffusion activities. Each activity has a cost in weeks associated with it. The weeks are marked off the calendar located on the right-hand side. The calendar spans from September to June, representing an academic calendar year. Below the calendar, there is a list of twelve staff members, eleven of which can become adopters after the player earns the corresponding points across the three adoption phases: awareness, interest, and trial/appraisal. A list of the activities and the staff members
available in this study’s DSG version is included in Appendix A.

Figure 3.2. Screenshot of the DSG interface. The small green squares located on the right side of the screen indicate the points earned on the path to convincing staff members to adopt the innovation.

To enable multiple participants playing the DSG from remote connections, the game was made accessible within Second Life. This 3D virtual world was selected over other technologies for the following reasons:

Through Second Life’s co-browsing capabilities, all players share the same DSG screen, and in this way, all of them see the same game status. When a player performs an action in the game by clicking a link or a button, the same action is reflected on the screen of the other players.

Second Life’s co-browsing capabilities also provide individual control over some of the elements within the game. For instance one player could be analyzing the social network diagrams included in the game while the other player could be looking at the
description of the staff members. Players can also zoom in or out of the game screen independently at any time. Moreover, Second Life provides VoIP allowing players to talk to each other through their avatars.

Figure 3.3 shows two participants playing the game collaboratively through their avatars within Second Life.

![Figure 3.3. Participants playing collaboratively within Second Life.](image)

**This Study’s DSG Version Pilot Tests**

Several pilot tests were conducted in order to detect any issues related to programming logic, usability, and communication, as well as to estimate the time needed to complete the game. In the first pilot test, 25 undergraduate students taking a Change Management class took a pre-test before being introduced to the diffusion of innovations topic and before playing the modified version of the DSG. Students played the game individually using a web browser. They took 24 minutes on average to complete the first game, obtaining two adopters. They played an average of six times; however, some
students played up to 30 times. Four students won the game by persuading all staff members to become adopters. Students reported no issues related to user interface or unexpected results from the actions taken. Only 12 students took the post test, obtaining statistically significant higher results than in the pre-test, $t(11) = 3.64, p = 0.0039$.

A second pilot test included 40 undergraduate students taking a summer course related to Change Management at a university in China. Students were seated next to each other and used one computer per pair. On average, the pairs took 50 minutes to complete their first game. The instructor, who was the same in both pilot tests, explained to the researcher that some reasons students in China needed longer than the students in the first pilot test included having a slow internet connection and a lack of English fluency (all the content on the game is in English). Each pair of students got on average two adopters during their first game. Students played an average of four games. After playing the game, they submitted anonymous surveys in which they reported having not encountered any programming glitches or unexpected issues.

A third pilot test that included six graduate students was conducted using Second Life. Four of them played the game in pairs and two played individually. The students playing in pairs were physically separated from each other. They communicated verbally through Second Life. No communication problems were detected when playing in pairs, except for a one to two-second lag for the screen to refresh on the remote computer. All participants played just one time. Those playing in pairs took an average of 31 minutes while those playing individually took 22 minutes. The game score of students playing in pairs was statistically significantly higher than those playing it individually $t(6) = 2.6063, p = 0.0403$. 
Participants

A total of 44 undergraduate and graduate students from eleven different academic departments at Indiana University participated in the study. Two methods were used to recruit participants: The first one consisted of posting flyers at the School of Library and Information Science, the School of Education, and the Department of Psychological and Brain Sciences. These academic departments were selected because they teach classes related to elements included in this study such as computer mediated communication, collaborative learning, and personality psychology. The second recruitment method consisted of posting a classified ad on the Indiana University OneStart website. This website can be accessed only by IU students, professors, and staff.

In order to be eligible to participate, students were informed that they (a) must be part of an undergraduate or graduate academic program (b) must have no prior knowledge of diffusion of innovations theory, as described by Rogers (2003) (c) must have not played any version of the Diffusion Simulation Game, (d) must be a native English speaker, (e) must be able to attend in person the specific computer lab in which the study will take place, and (f) must be at least 18 years old.

As part of the recruiting process, students were offered eight dollars per hour for a total of three hours. Those who were interested in participating in the study contacted the researcher via email. The researcher sent them the informed consent form, which included detailed information about the study. The informed consent form is included in Appendix B.

The summary of participants’ demographic information is included in Table 3.1. As it can be observed from this table, the number of male and female participants was
very close; the majority of them were between 18 and 25 years old (93%), most of them were undergraduate students (82%), and more than half of them play digital games from one to two hours per week (57%).

Table 3.3  
**Participant's demographic information summary**

<table>
<thead>
<tr>
<th></th>
<th>Total</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Gender</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>24</td>
<td>55%</td>
</tr>
<tr>
<td>Male</td>
<td>20</td>
<td>45%</td>
</tr>
<tr>
<td><strong>Age</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>18 – 25 years old</td>
<td>41</td>
<td>93%</td>
</tr>
<tr>
<td>26 – 30 years old</td>
<td>2</td>
<td>4%</td>
</tr>
<tr>
<td>36 – 40 years old</td>
<td>1</td>
<td>2%</td>
</tr>
<tr>
<td><strong>Academic Level</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Undergraduate</td>
<td>36</td>
<td>82%</td>
</tr>
<tr>
<td>Graduate</td>
<td>8</td>
<td>18%</td>
</tr>
<tr>
<td><strong>Digital Game Experience</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Not played within a year</td>
<td>11</td>
<td>25%</td>
</tr>
<tr>
<td>From 1 to 2 hours/week</td>
<td>25</td>
<td>57%</td>
</tr>
<tr>
<td>From 6 to 10 hours/week</td>
<td>7</td>
<td>16%</td>
</tr>
<tr>
<td>From 11 to 15 hours/week</td>
<td>1</td>
<td>2%</td>
</tr>
</tbody>
</table>

Regarding their level of familiarity with the virtual world Second Life, only 16% had previously used it. However, none of the participants had used it more than five times.

Since the context of the game used in this study is related to the diffusion of innovations in a high school, participants were also asked whether they had any previous experience working at a school for at least a year and whether they have had any experience proposing and implementing new ideas in their work environment. Twenty five per cent of the participants had previous experience working at a school for at least a year, either as teachers or staff. Forty seven percent of them stated having previous experience diffusing new ideas in their work places.
Instruments

The instruments used in this study consisted of: A modified version of the DSG, demographic data survey, personality trait questionnaire, pre-/post-test measuring knowledge about the diffusion of innovations theory, and game experience reactionnaire. These instruments are explained in the following sub-sections.

Modified Version of the DSG

As previously explained in this chapter, a multiplayer version of the DSG was developed for this study. The goal of the game remained the same: players needed to persuade all staff members to become adopters of peer-tutoring as an instructional innovation. However, using just the number of total adopters was not an accurate indicator of game performance because it did not account for how close all staff member in the game were from becoming adopters. For instance, it is possible to have no adopters at all while having all staff members very close to adoption. On the other hand, it is also possible to have one adopter while most staff members are just on the initial phase of adoption.

Instead of the number of adopters, the indicator used to measure game performance was the total number of adoption points obtained in a game session. Adoption points were calculated as the sum of proportions between the numbers of points that each player obtained per each staff member divided by the total number of actual points needed to get each specific staff member as an adopter. For example, the principal requires eleven points to become an adopter. A player who had only gained five points would have scored 5/11 for the principal. This calculation was repeated for all staff members to obtain the overall adoption points per game session. The adoption points
were automatically calculated by the DSG computer program during each player’s turn and stored in a log file.

**Demographic Data Survey**

This instrument consisted of a questionnaire that was used to collect participants’ basic demographic information (gender, age, academic program, and academic level, among others), and their previous knowledge or experiences in areas related to the current study such as experience implementing new ideas or innovations in the work environment, experience playing strategy games, and experience using Second Life (see Appendix C).

**Personality Trait Questionnaire**

The instrument used to measure participants’ personality traits was John’s et al. (2008) Big Five Inventory (BFI) which is included in Appendix D. This instrument consists of 44 items that measure the personality traits of agreeableness, conscientiousness, extraversion, neuroticism, and openness. The instrument includes items such as “I am someone who is reserved” and uses a multiple choice Likert-type scale. The mean alpha reliability of this instrument is 0.83, which is comparable to the reliability of other widely used personality instruments such as the NEO-PI-R, the NEO-FFI and the TDA.

**Pre-/Post- Test**

A 15-item pre-/post- test (see Appendix E) was used to measure the knowledge about the diffusion of innovation theory that participants had before and after playing the Diffusion Simulation Game. Some of the questions included in the test were adapted from an instrument used to identify learning gains from the original DSG board version
(Molenda & Rice, 1979). Other questions had been used in a previous study that measured learning acquired across playing the original DSG version multiple times (Lara, Enfield, Myers, & Frick, 2010).

To verify the validity of this instrument, four graduate students with considerable knowledge in the Diffusion of Innovations theory took the test separately. The original proposed test consisted of sixteen items. However one item was removed so that only items that had at least 75% of inter-agreement were included. Nine out of the fifteen items had a 100% inter-agreement. Fleiss’ kappa inter-rater agreement was 0.84.

The test measured conceptual and procedural knowledge related to the diffusion of innovations theory such as stages of adoption, adopter types, and application of diffusion activities. Using a context similar to the DSG, participants were given a list of teachers with a brief description of each of them and a list of activities that they could use in order to influence them to adopt an instructional innovation.

Thirteen out of the fifteen items were multiple-choice and two were open-ended questions. To lessen the potential issue of having some participants selecting their answers haphazardly on the multiple-choice questions and without reading the material provided (i.e. list of teachers and activities), additional open-ended questions asking them the reason for selecting their answers were added. However, these open-ended questions were not assessed.

The time needed to complete the test had been observed during the pilot tests. Participants had taken an average of 25 minutes to complete the pre-test and an average of 15 minutes for the post-test.
Game Experience Reactionnaire

This instrument was used to collect participants’ reactions and attitudes about their game experiences. All of the questions except one were Likert-type scale, ranging from “Strongly Disagree” to “Strongly Agree”. The last question was an open-ended question concerning the reasons for their preferences of playing the game either individually or collaboratively.

The first six questions were the same for all participants regardless of whether they had played the game individually or collaboratively. These questions were intended to measure their level of enjoyment of playing the game and the extent to which they considered having learned from playing the game. Some of the questions included “If given the chance, I would like to play the game more.” and “I think playing the game was an effective way to learn.”

A second set of questions was used to measure the extent participants liked playing in the way they did, either individually or collaboratively. These questions were different for each group setting. For example, participants playing collaboratively were given a question which read “I felt more motivated playing the DSG as part of a team than if I had played alone.” whereas those playing individually were given the question “I feel that I would have been more motivated playing this game with somebody else instead of playing it alone.”

Some of the questions on the second set were adapted from an attitudinal survey used by Brewer and Klein (2006). The reactionnaires used by participants in the collaborative and individual settings are located in Appendixes F and G, respectively.
**Procedure**

Participants attended two different sessions: an initial session which lasted thirty-five minutes and a game session which lasted on average two hours and twenty minutes. This study used a laboratory design, firstly, to control extraneous factors (e.g., bandwidth speed, network issues), and secondly, to be able to use screencast software to record the screens of the participants while they played the DSG. These sessions were conducted in an audio-editing lab of the School of Education and in the video-editing computer lab of the IST department. The activities included in the initial and the game sessions are described below.

**Initial Session**

An initial session was scheduled with each student after confirming by email a willingness to participate in the study. These sessions took place in the video-editing computer lab of the IST department at the School of Education. In these initial sessions participants signed the informed consent form and completed the following instruments:

1. Demographic data and previous general knowledge questionnaire - Participants took two minutes on average to complete this questionnaire.

2. Personality trait questionnaire - Participants were told to answer the items as honestly as possible and without investing too much time thinking about their answers. Participants took three minutes on average to complete this 44-item questionnaire.

3. Pre-test measuring previous knowledge about the diffusion of innovations theory - Participants were told that they were not expected to know all of the answers and that they could select the “I don’t know” option from the multiple choices provided for
some of the questions. Participants were not given a specific amount of time to complete the pre-test. The researcher left the room so that each participant could take the pre-test in private and asked participants to send him a text message via Instant Messenger once they had finished. Participants took nineteen minutes on average to complete the 15-item pre-test.

After completing the three instruments, the researcher assigned the participants randomly into a setting group by a coin toss. Before the coin toss, each participant was informed that for “heads” he/she would be playing the game individually whereas for “tails’ he/she would be playing with a partner. This random assignment process was not used for the last six participants because the total number of players in the collaborative setting had already been reached. For this reason, the last six participants were placed in the individual setting.

In order to explore the relationship between the level of agreeableness and their performance, participants in the collaborative treatment were paired off with someone else who, based on the personality test, had a similar level of agreeableness. As explained in the previous chapter, agreeableness refers to concepts such as trusting, politeness, and willingness to cooperate (Barrick & Mount, 1991). Participants were not told about the criteria used to form the pairs. Seven out of the eleven dyads in the collaborative setting were composed of a male and a female. In three dyads both participants were male whereas both were female in one dyad. In the individual setting, there were fifteen female and seven male participants.
Game Session

It took from two days to four weeks after the initial session to schedule the game sessions depending on participants’ availability, researcher’s availability, and the time needed to find a partner with a similar level of agreeableness for participants in the collaborative setting. Thirty minutes before each game session, the researcher prepared and tested all of the equipment and software needed, including: headset to record participants’ voices, screencast application to record each participant’s interaction with the game, Second Life which provided the virtual environment to communicate while playing the game, and the DSG board which contained the actual game.

Since most participants did not have a Second Life account and in order to prevent external potential perception effects based on multiple avatars’ shapes and appearances, a set of basic male and female avatars having similar body mass, size and clothing were created by the researcher (Figure 3.4). When two participants collaborated who were the same gender, a very similar avatar was created with different hair color and skin tones.

Figure 3.4. Second Life avatars used in the study.
Team setting game session. Participants in the team setting played the game from two different computer labs at the School of Education. They never met one another in person. All the interaction took place through their Second Life avatars. After arriving at the computer lab each participant had been assigned, the researcher and an assistant took five minutes to explain how to move around in Second Life and how to zoom in and out from the DSG board.

The researcher welcomed both players using his Second Life avatar from a third computer, and asked them to zoom into the DSG board, which was displaying the agenda for the session (see Figure 3.5).

Figure 3.5. Team setting agenda screenshot.

The team setting agenda included the following activities:

1. Getting to know one another by using an icebreaking activity
The participants in the team setting were given ten minutes to become acquainted through a virtual icebreaking activity, which the researcher adapted from the activity Get-to-know-yourself Bingo! by Realityunfiltered (2009).

The activity consisted of a game that had a 4 x 4 grid of yellow spheres, as shown on Figure 3.6. Players’ avatars were facing each other with the grid in the middle. Taking turns, each player touched a sphere and read aloud a question that appeared in the bottom left corner of the screen. If both players had a common answer, the sphere turned green; otherwise, it turned red. The color change was performed manually by the researcher. Players had to wait until that question disappeared before touching another sphere. While waiting, they had to keep elaborating on their answers. Examples of questions were “What is your middle initial?”,”Do you have any pets?””, and “Do you play any musical instrument?” Their goal, as a team, was to have three consecutive green spheres (horizontally, vertically or diagonally).

Participants took from five to ten minutes to complete this activity.

Figure 3.6. Participants interacting in the icebreaking activity.
2. Becoming familiar with the mechanics and rules of the DSG

After completing the icebreaking activity, the researcher asked players to zoom into the DSG board, which was displaying the DSG login screen. Players were given a username and one of them logged into the game. For five minutes, players conducted three to four information and diffusion activities, becoming familiar with the process of playing the game.

3. Playing the DSG for the first time

Once participants became familiar with the game, the agenda screen was shown again. Prior to playing the game for the first time they were informed that:

   a) The goal was not only to win the game but also to learn strategies to convince or persuade people to adopt an idea or innovation.

   b) In order to encourage the participants to do their best while playing the game, they were told that there would be two types of rewards: The first reward was the possibility of winning a $50 raffle ($25 per player) if the team obtained at least eight adopters in the game and each team member answered at least ten questions correctly on the post-test. Emphasis was made that both of them needed to get at least ten questions correct in order to participate in this first raffle. The second reward was becoming eligible to participate in a second $50 raffle ($25 per player) if their team was among the three teams with the highest game and post-test scores. Several other studies have reported a potential increase in test scores by offering monetary incentives (Duckworth et al., 2011, Liu et al., 2012).

   c) The following roles were suggested: Strategy analyzer and resource coordinator. The Strategy analyzer role consisted of writing down identified
strategies that seemed to work as well as those that did not to avoid repeating them whereas the resource coordinator role consisted of paying attention to the resources available in the game, such as the time remaining to complete it (both the 40-minute real-time limit and the number of weeks left within the DSG), and assuring equal participation in the decision process.

The participants were given 40 minutes to complete their first game session. They were told that the remaining extra minutes would be added to the second time they would be playing the game as shown in the agenda. From previous pilot tests it was estimated that participants in the team setting would take from 30 to 40 minutes to play the game for the first time.

4. Taking a five-minute break

After completing playing the DSG for the first time, all participants were given a five-minute break. During this break a soft drink or bottled water and light snacks were provided.

5. Reflecting and planning interaction

Participants were asked to answer and discuss the following six questions, which were shown on the DSG panel within Second Life: How well did we collaborate in our previous game play? Did we both participate equally in our game play? How can we improve our collaborative process? What seemed to work and what did not? How can we improve our game play? What are we learning from this game? These questions were mainly aimed at promoting and facilitating group processing by trying to identify some areas in which the quality of teamwork could be improved (Johnson, Johnson, & Smith, 1998).
6. Playing the DSG multiple times

Participants played the DSG for as many times as they wanted using forty minutes plus the remaining minutes they had left from the first time they played. In this way, all participants from both settings (individual and collaboratively) were given 80 minutes in total to play the game. They were told that they could restart the game at any point. In other words, they did not have to finish a game before being able to start a new one. Participants were informed that only their highest score would count towards being eligible for the awards. The researcher notified participants when they had just ten minutes left to play the game.

7. Submitting the reactionnaire

After completing the game session, each participant opened an Internet browser and accessed the reactionnaire. The reactionnaire consisted of fifteen Likert-scale questions and one open-ended question. The first six questions were aimed at measuring their level of enjoyment of playing the game while the remaining nine was aimed at measuring the extent they considered that having played the game collaboratively had been helpful, effective, and enjoyable.

8. Taking the post-test

The last instrument submitted by participants was the post-test, which measured how much understanding and knowledge each of them had gained by playing the DSG collaboratively. Before taking the post-test, the researcher had removed the DSG panel from Second Life to prevent participants from referring to it. The post-test included the same items as the pre-test. Participants took an average of nine minutes to complete the post-test.
**Team collaboration elements.** To encourage collaboration between the participants playing in pairs, several elements of the cooperative learning and CSCL theories were implemented. These elements are presented here:

a) Building positive interdependence

Positive interdependence has been identified as the most important factor of any cooperative learning task (Johnson et al., 1994). Positive interdependence entails that participants need to realize that the only way to succeed as a team is through a joint effort. The following types of positive interdependence were implemented in the team game session:

*Goal interdependence:* In the game session, participants were informed that their goal was both (1) to obtain the maximum number of adopters, and (2) to learn concepts and effective strategies related to the diffusion of innovations theory. Moreover, they were told that in order to accomplish these goals, it was necessary to work as a team.

*Reward interdependence:* Prior to playing the game, participants were told that their team could be eligible to participate in two $50 raffles based on both their performance as a team in the game and their individual performances on the post-test. Participants were not informed about these raffles before the game session to prevent them from potentially attempting to improve their performance by getting more familiar in advance about the diffusion of innovations theory or the DSG.

*Role interdependence:* Prior to playing the game, participants were given suggestions as how to implement the roles of strategy analyzer and resource coordinator. The strategy analyzer had to identify and write down effective
strategies whereas the resource coordinator had to ensure equal participation as well as to pay attention to the time available to complete the game. However these roles were not enforced.

*Peer interdependence:* To promote equal participation for both players, the researcher designed the game requiring them to interact with the game interface by alternating turns. A turn consisted of selecting an “Information” or a “Diffusion” activity along with the desired staff members and clicking on the “Conduct Activity” button. After the activity was completed, the “Feedback page” was shown describing the outcome of the activity. The player who initiated the turn could not do anything else after getting the “Feedback” page but had to wait until the other player clicked on the “Switch Turn” button. This button was only displayed on the screen of the player who had not initiated the previous turn. This mechanism was aimed at preventing one participant from taking control over playing the entire game. During the five minutes that players had for becoming familiar with the game, the researcher explained to them how they would be taking turns by clicking on the “Switch Turn” button. He also explained that this button only indicated that it was the other player’s turn to interact with the interface but that both of them had to decide together the activity to conduct next.

b) Providing an opportunity for group processing

Group processing allows team members to reflect upon their individual contribution to obtaining the goal and also their work as a team in order to identify as a group ways to improve their performance (Johnson et al., 1998). In
this study, after playing the DSG for their first time, players were required to answer and discuss six questions about their collaboration process.

c) Including individual accountability

Individual accountability refers to each team member’s awareness of being held responsible for the mastery of the instruction provided (Johnson et al., 1998). In this study, players were notified that they would take individual post-tests after completing the game session. They were also informed that in order for both players to be eligible to participate in one of the raffles, both of them needed to get at least ten questions correct on the post-test.

d) Building trust

Mutual trust has been identified as an essential component of teamwork (Brown, Poole & Rodgers, 2000; Spencer, 2001). Instead of having both participants playing the game without knowing one another, they interacted in the icebreaking activity previously explained. When completing this activity they had identified at least three similarities between them (playing the same instrument, having the same type of pet, etc.).

**Individual setting game session.** Participants playing the game individually went through a similar process as those playing it in pairs. They also used the game interface through Second Life. The items in the agenda were the same except for the first item (getting to know each other), which was removed. Specifically, the individual sessions consisted of:

1. Having a five-minute period to become familiar with the mechanics and rules of the DSG.
2. Playing the DSG for the first time for up to forty minutes

Similar to the collaborative setting, prior to playing the game for the first time, individual players were told about (a) the game goals, (b) the rewards, (c) paper and pen available for note taking.

3. Taking a five-minute break in which a soft drink and snacks were provided by the researcher.

4. Reflecting and planning for five minutes

Different from the dyad setting in which participants were asked to discuss their collaboration level, individual players were asked three reflective questions about their game performance: What seemed to work and what did not? How can I improve my game play? What am I learning from this game?

5. Playing the DSG multiple times

Individual participants were also able to play the DSG as many times as they wanted during a forty-minute period plus the remaining minutes they had left from the first time they played. They were told that only their best game would count towards being eligible for the awards.

6. Submitting the reactionnaire

The reactionnaire for the individual setting consisted of eleven Likert-scale questions and one open-ended question. The first six questions were exactly the same as the collaborative setting since these questions measured their level of enjoyment of playing the game. The remaining five questions measured the extent to which they found helpful, effective, and enjoyable playing the game alone and whether they would have preferred playing it with someone else.
Taking the post-test

The post-test included the same 15 items included in the pre-test. Participants were given as much time as needed to complete the post-test.

Data Analysis

This section describes the diverse data sources and statistical approaches used to answer each of the research questions:

Research Question 1

Are there any differences in game performance, learning, and attitudes among students playing an online instructional game individually versus playing it in dyads while following a collaborative script?

The following table summarizes the different sources used to address this question:

Table 3.4  
*Summary of sources used to address the first research question*

<table>
<thead>
<tr>
<th>Sources</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Game Performance</td>
<td>DSG MySQL database</td>
</tr>
<tr>
<td></td>
<td>All game interaction and scores were recorded in a MySQL database</td>
</tr>
<tr>
<td>Learning</td>
<td>Pre-test, Post-test</td>
</tr>
<tr>
<td></td>
<td>Learning gains were calculated as the difference between the post-test and the pre-test</td>
</tr>
<tr>
<td>Attitudes</td>
<td>Reactionnaire</td>
</tr>
<tr>
<td></td>
<td>The Likert-type items in the reactionnaire were used to create attitudinal scales</td>
</tr>
</tbody>
</table>

Game Performance – As mentioned in previous sections, the most accurate indicator to measure game performance in the DSG is the number of adoption points earned. The computer program of the DSG version used in this study included the
calculation of the adoption points earned on each turn and the subsequent recording of the adoption points into a MySQL database. Additional data stored on each turn included:

- username,
- number of games played,
- activity conducted,
- cost associated with the activity conducted,
- weeks elapsed,
- number of adopters,
- staff members who earned points,
- number of points earned,
- and the timestamp the turn was conducted. The following figure shows a screen capture of the MySQL database used.

![MySQL database screen capture with logs of turns played](image)

**Figure 3.7. DSG MySQL database screen capture with logs of turns played**

**Learning** – Students’ gains in learning were measured by the difference in scores between the post-test and the pre-test. Students took these tests using an online form and their responses were stored upon the test submission. Thirteen out of the fifteen questions included in the test were multiple choice. A Microsoft Excel spreadsheet template was used to automatically evaluate these closed-ended questions. In the remaining two questions, students had to type their answers. The researcher graded these questions manually using a rubric.
An Instructional Systems Technology (IST) doctoral candidate assisted the researcher in verifying that the Excel template was grading the questions correctly. Moreover, in order to determine the reliability of the two fill-in-the-blank questions, she randomly selected and graded 10% of the tests, without knowing whether the tests were pre- or post- tests. The Cohen Kappa coefficient was .85.

Cronbach’s alpha internal consistency reliability of the test was 0.690 including all 15 items. The value of alpha increased to 0.709 after removing item 9.

Attitudes – Students’ attitudes towards their enjoyment playing the DSG and towards having played in the assigned setting were measured by a survey that was submitted online. The following six questions were included in the form to measure the extent to which students enjoyed the game:

1. The game was difficult.
2. I enjoyed playing the game.
3. If given the chance, I would like to play the game more.
4. I think playing the game was an effective way to learn.
5. The game does not reflect reality.
6. The game interface was confusing.

The reliability of the scale with the six questions was .45, which was very low. The reliability analysis indicated that by removing the question regarding the game being difficult, the reliability would increase to .62. This was because players could have found the game difficult in the sense of being challenging but still having enjoyed it. After removing that question along with the question of the game interface being confusing, the scale had a Cronbach’s alpha reliability of 0.805, as shown in the following table.
Table 3.5
Reliability coefficient for participants' attitudes towards playing the DSG

<table>
<thead>
<tr>
<th>Item</th>
<th>Scale Mean if Item Deleted</th>
<th>Scale Variance if Item Deleted</th>
<th>Corrected Item-Total Correlation</th>
<th>Cronbach's Alpha if Item Deleted</th>
</tr>
</thead>
<tbody>
<tr>
<td>Game Enjoyment</td>
<td>15.22</td>
<td>5.156</td>
<td>.550</td>
<td>.455</td>
</tr>
<tr>
<td>Play More</td>
<td>15.43</td>
<td>4.018</td>
<td>.586</td>
<td>378</td>
</tr>
<tr>
<td>Effective way to learn</td>
<td>15.22</td>
<td>4.645</td>
<td>.496</td>
<td>.451</td>
</tr>
<tr>
<td>Doesn’t reflect Reality (Reversed)</td>
<td>15.50</td>
<td>5.233</td>
<td>.515</td>
<td>.469</td>
</tr>
<tr>
<td>Confusing Interface (Reversed)</td>
<td>15.79</td>
<td>6.957</td>
<td>-.122</td>
<td>.805</td>
</tr>
</tbody>
</table>

The following five items were used to measure the attitudes towards having played individually:

1. If I had to play the game again, I would prefer to keep playing it alone rather than with a remote teammate.
2. I believe I can learn more effective strategies about getting people to adopt an innovation by playing the game individually rather than with a remote teammate.
3. I feel that I would have been more motivated playing this game with somebody else instead of playing it alone.
4. I could have performed better in the game if I had played with a teammate (another player in Second Life) instead of playing by myself.
5. I would have been more committed to do my best when playing with a teammate rather than playing it alone.

Participants’ responses for the last three items were reversed in order to compute the coefficient of reliability of these items which, when removing the last item, was .89. The following table shows the reliability coefficient of the scale used to measure the attitudes towards having played individually.
Table 3.6
Reliability coefficient for participants' attitudes towards playing individually

<table>
<thead>
<tr>
<th></th>
<th>Scale Mean if Item Deleted</th>
<th>Scale Variance if Item Deleted</th>
<th>Corrected Item-Total Correlation</th>
<th>Cronbach's Alpha if Item Deleted</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prefer Playing Alone</td>
<td>11.68</td>
<td>11.56</td>
<td>.781</td>
<td>.799</td>
</tr>
<tr>
<td>Learn More Alone</td>
<td>11.68</td>
<td>12.89</td>
<td>.691</td>
<td>.825</td>
</tr>
<tr>
<td>More Motivated Not Alone (Reversed)</td>
<td>11.22</td>
<td>12.18</td>
<td>.785</td>
<td>.800</td>
</tr>
<tr>
<td>Perform Better Not Alone (Reversed)</td>
<td>11.77</td>
<td>12.56</td>
<td>.727</td>
<td>.815</td>
</tr>
<tr>
<td>More Committed Not Alone (Reversed)</td>
<td>11.27</td>
<td>15.06</td>
<td>.404</td>
<td>.890</td>
</tr>
</tbody>
</table>

The participants who played the game collaboratively answered the following items:

1. I would have achieved better results if I had played the DSG alone.
2. If I were to play the DSG again, I would prefer playing it just by myself.
3. I felt I was more committed to do my best when playing with a teammate than if I had played alone.
4. Playing the game with somebody else was the most effective way to learn from the gaming experience.
5. I was able to learn more concepts and understand effective strategies related to the diffusion of innovations by working with my teammate.
6. I felt more motivated playing the DSG as part of a team than if I had played alone.
7. As a team, we generated more and better ideas to get more adopters than I could have done alone.
The following table shows that the items used to measure the attitudes towards having played in a team had a high reliability coefficient (\textit{alpha} = .91) once the last item was removed.

Table 3.7 \textit{Reliability coefficient for participants’ attitudes towards playing in teams}

<table>
<thead>
<tr>
<th></th>
<th>Scale Mean if Item Deleted</th>
<th>Scale Variance if Item Deleted</th>
<th>Corrected Item-Total Correlation</th>
<th>Cronbach’s Alpha if Item Deleted</th>
</tr>
</thead>
<tbody>
<tr>
<td>Perhaps better alone (Reversed)</td>
<td>20.09</td>
<td>24.37</td>
<td>.77</td>
<td>.82</td>
</tr>
<tr>
<td>Prefer playing alone (Reversed)</td>
<td>20.18</td>
<td>23.01</td>
<td>.78</td>
<td>.81</td>
</tr>
<tr>
<td>Teamwork most effective</td>
<td>19.68</td>
<td>24.98</td>
<td>.83</td>
<td>.81</td>
</tr>
<tr>
<td>Learned more in a team</td>
<td>19.45</td>
<td>27.02</td>
<td>.62</td>
<td>.84</td>
</tr>
<tr>
<td>More motivated in a team</td>
<td>19.77</td>
<td>26.37</td>
<td>.69</td>
<td>.83</td>
</tr>
<tr>
<td>Had more ideas in a team</td>
<td>19.59</td>
<td>27.87</td>
<td>.68</td>
<td>.84</td>
</tr>
<tr>
<td>More Commitment in a team</td>
<td>19.77</td>
<td>32.18</td>
<td>.133</td>
<td>.91</td>
</tr>
</tbody>
</table>

Research Question 2

What is the relationship between personality traits and performance, learning and attitude in students playing an online instructional game in both settings (individually and collaboratively)?

The data source used to answer this question was John’s et al. (2008) Big Five Inventory (BFI), which participants completed and submitted online. John et al. (2008) reported an alpha reliability of this instrument of .83. Moreover, the authors provided directions about the items that need to be reversed and combined to create the scales for each of the five personality traits. The accuracy of the process used to calculate the personality trait scales was verified and confirmed by an IST doctoral candidate.
Research Question 3

Are there any common patterns in the game play strategies used by students within each setting (individual or collaborative)? What are the main pattern differences between students with the highest and lowest scores?

The screencasts that were recorded while students played the game were used as a data source to address this question. Specifically, the researcher transcribed and analyzed all the game sessions from those players with the top two, middle two, and lowest two average game scores (as measure by the number of adoption points) per setting.

Analysis of Patterns in Time (APT), which is a method of recording and quantifying temporal relations about observable phenomena (Frick, 1990), was used to identify patterns between players with the highest and lowest scores in both settings. In APT, patterns are identified by counting the occurrences of multiple states that characterized the phenomena or event observed (Frick, 1983). A set of states that are mutually exclusive and exhaustive comprises what Frick (1983) defines as a “classification” in APT. For instance, in a study conducted by Frick (1990), trained observers collected behavioral data on 25 elementary students at one-minute intervals. The APT classifications used were the type of available instruction (direct, non-direct, none), and the student orientation to academic instruction (engaged, non-engaged, non-academic engagement). Through APT analysis, it was possible to observe that “students were on task 97% of the time if some form of direct instruction was occurring also, whereas they were on task only 57% of the time during non-direct instruction.” (p. 1).

APT classifications in the collaborative setting. To identify the APT classifications used for the analysis of patterns in the collaborative setting, the researcher
referred to the literature in interaction and discourse analysis (Gunawardena, Lowe, and Anderson, 1997; Hara, Bonk, & Angeli, 2000; Henry, 1992; Herring, Kutz, Paolillo, & Zelenkaukskaite, 2009; Murphy, 2004). The following table includes the different classifications that were identified. Each of them is described below.

**Table 3.8**  
*List of classifications used for APT analysis in the collaborative setting*

<table>
<thead>
<tr>
<th>Classification</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Collaboration level</td>
<td>Extent to which team mates collaborated in deciding the activity to conduct in a turn.</td>
</tr>
<tr>
<td>Decider</td>
<td>Player(s) who made the decision to conduct the activity in the turn</td>
</tr>
<tr>
<td>Suggestions</td>
<td>Player(s) who made suggestions during the turn</td>
</tr>
<tr>
<td>Turn Reason</td>
<td>Reason why dyads selected the activity conducted in each turn.</td>
</tr>
<tr>
<td>Diffusion Strategy Selection</td>
<td>Whether the activity conducted was appropriate according to diffusion of innovations theory (i.e., in order to succeed in the game), and if not, why</td>
</tr>
</tbody>
</table>

*Collaboration Level* – The level of collaboration between players was identified as classification based on studies conducted by Gunawardena et al. (1997) and Herring et al. (2009). Gunawardena et al. (1997) developed an interaction analysis model (IAM) to examine meaning negotiation in online asynchronous communication. This model includes five phases: sharing information, exploring inconsistencies among participants, negotiation of meaning, testing of proposed synthesis, and statements of agreement and application of the co-constructed meaning.

Herring et al. (2009) conducted a study that involved the interaction analysis of text-based synchronous communication in a massive multiplayer online game. In that
study, by analyzing sequences of utterances, the researchers found that the second most frequent thematic content of all communication among players was ‘negotiation of game play’. An example of such negotiation included the exchange of messages among players to re-configure their team after two of the players had left the game.

Collaboration level was used as a classification to measure the extent to which players collaborated in conducting the activity corresponding to the turn in question. Based on Gunawardena’s et al. (1997) IAM model, the collaboration level was coded as “Negotiation” when both players did any of the following: (1) shared information, (2) expressed inconsistencies, (3) negotiated their turn, (4) participated in the selection of the activity and staff members. The descriptions of the remaining categories included in this classification along with an example of each of them are presented in the following table.

Table 3.9

<table>
<thead>
<tr>
<th>Category</th>
<th>Description</th>
<th>Example</th>
</tr>
</thead>
</table>
| Negotiation (N)        | The activity is conducted as a result of dialog or discussion between players that includes sharing information, elaborating a suggestion, expressing different opinions, participating in the decision process, and identifying inconsistencies. | -Should we do a Demonstration?  
-It sounds good… but with whom? Probably the Math Teacher?  
-Yeah, let’s do it with him! |
| Passive Negotiation (PN)| A player suggests conducting an activity and the other player consents without any dialog. The suggestion is usually presented as a question. | -Should we do a Pilot Test?  
-Okay, go for it. |
| Unilateral Decision (U) | In his/her turn, a player conducts an activity (which was not previously discussed) without the other player’s opinion. | -I’ll talk to the Principal now. |
| Command (C)            | In the other player’s turn, a player commands him/her to conduct an activity. | -Do a Blog Post |
**Turn Decider Classification** – This classification indicated which player had made the decision to select the specific activity and the staff members within the turn. In each turn, at least one of the players must make the decision about the activity to be conducted. The following table includes the categories used in this classification.

Table 3.10
*APT categories in the Turn Decider classification*

<table>
<thead>
<tr>
<th>Category</th>
<th>Description</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Player 1 (P1D)</td>
<td>Player 1 made the decision.</td>
<td>P1: Let’s do a Demonstration</td>
</tr>
<tr>
<td></td>
<td></td>
<td>P2: Okay</td>
</tr>
<tr>
<td>Player 2 (P2D)</td>
<td>Player 2 made the decision.</td>
<td>P1: Let’s do a Demonstration</td>
</tr>
<tr>
<td></td>
<td></td>
<td>P2: Actually I think a Presentation would be more effective</td>
</tr>
<tr>
<td>Both (BD)</td>
<td>Both players contributed in making the decision. This is the case when for</td>
<td>P1: Should we do a Demonstration?</td>
</tr>
<tr>
<td></td>
<td>example, one player decides how to conduct the activity and the other player</td>
<td>P2: It sounds good… but with whom? Probably the Math Teacher?</td>
</tr>
<tr>
<td></td>
<td>selects the staff members.</td>
<td>P1: Yeah, let’s do it with him!</td>
</tr>
</tbody>
</table>

**Turn Suggestions Classification** – This classification indicated whether players had made any suggestions during the turn. Suggestions included proposing conducting an activity, selecting a staff member, or planning in doing something (e.g.: “Let’s try to identify who is more open to new ideas so we can try to persuade that teacher first.”)

When a player merely described what he or she was about to do or have already done, it was not considered as a suggestion. This classification included the categories shown in the following table.
Table 3.11  
*APT categories in the Turn Suggestions classification*

<table>
<thead>
<tr>
<th>Category</th>
<th>Description</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Player 1 (P1S)</td>
<td>Player 1 made one or more suggestions.</td>
<td>P1: I think we should get the Personal Information for all staff members.</td>
</tr>
<tr>
<td>Player 2 (P2S)</td>
<td>Player 2 made one or more suggestions.</td>
<td>P2: Shall we take a look at the lunch mate network to find out who eats with whom?</td>
</tr>
<tr>
<td>Both (BS)</td>
<td>Both players made at least one suggestion.</td>
<td>P1: I think we should get the Personal Information for all staff members once more. P2: Well, the last three are very difficult to persuade. Probably we could skip those for now.</td>
</tr>
<tr>
<td>None (NS)</td>
<td>Neither player made any suggestions.</td>
<td>P1: I just conducted a Demonstration but it didn’t work. P2: I’ll talk to the Principal now.</td>
</tr>
<tr>
<td>Null</td>
<td>Neither player talked during the turn.</td>
<td></td>
</tr>
</tbody>
</table>

**APT classifications in both settings.** The following classifications were used in the individual and collaborative settings.

*Turn Reason Classification* - this classification indicated the potential reason players conducted a specific activity on each turn. The following table includes the different categories used along with a brief description and an example of each of them.
Table 3.12
*APT categories in the Turn Reason classification*

<table>
<thead>
<tr>
<th>Category</th>
<th>Description</th>
<th>Example</th>
</tr>
</thead>
</table>
| Previous Turn (PT)     | Players make a reference to a previous similar activity outcome for selecting the activity being conducted. The activity could be from a previous game. | -Shall we do a *Blog Post*?  
-Yes, that’s how we started last time too and it worked very well |
| Exploring (X)          | Players don’t have a clear expectation of conducting the activity.           | -What’s the *Blog Post* for?  
-I’m not sure… let’s do it and what happens. |
| Game Feedback (GF)     | Players conduct an activity based on the feedback provided by the game itself. | -Ah! We need to talk to the Secretary in order to talk to the Principal.  
-Ok. I’ll talk to her |
| Cognitive (C)          | The activity is conducted based on reasoning that: (1) is explicitly stated and (2) is not based on something learned from previous games (PG) | -I don't think that *Lunchmates* or *Committees* matters.  
-I guess it might if someone is in a *Committee* and talks to the rest of the people in that *Committee*. |
| Continuing Strategy (CS)| This activity is conducted as part of a set of activities that players had identified in a previous turn. Players could conduct the activity in silence. | -Let’s get *Personal Information* for all of them first  
(Players take three turns getting personal information) |
| Unknown (UK)           | There is no clear reasoning for the selection of this activity.              | -Let’s do a *Blog Post*. |

*Diffusion Strategy Selection Classification* – This classification indicated whether or not a turn was theoretically appropriate in terms of contributing to the global goal of getting all staff members to become adopters, according to diffusion of innovations theory by Rogers (2003). This classification consisted of one Effectiveness category and
four Non-effectiveness categories, which are described in the following table.

Table 3.13  
**APT categories in the Diffusion Strategy Selection classification**

<table>
<thead>
<tr>
<th>Category</th>
<th>Description</th>
<th>Example</th>
</tr>
</thead>
</table>
| Effective (E)          | This category was used when the strategy conducted in the turn was appropriate. To determine the appropriateness of the strategies used on each turn, this study used an adapted version of the strategies identified by Myers (2012) as being effective in the DSG as well as being aligned to the diffusion of innovations theory. | Strategy 1: Target staff members who are opinion leaders or earlier adopters to work toward critical mass.  
Strategy 2: Use Information Activities (i.e. Personal Information, Lunchmates, and Committees) early in the game.  
Strategy 3: Use Blog Post to gain points in the Awareness and Interest phases among earlier adopters.  
Strategy 4: Use the Presentation activity early in the game to gain points in the Awareness and Interest stages among earlier adopters.  
Strategy 5: Use the Demonstration activity by an opinion leader, to gain points in the Interest phase for other potential adopters.  
Strategy 6: Use the Site Visit activity to gain points in the Interest phase and move into the Trial phase.  
Strategy 7: Use the Pilot Test activity to gain additional points for those who have gained points in the Interest or Trial stages.  
Strategy 8: Use the Training Workshop activity to gain points in the Trial stage.  
Strategy 9: Target gatekeepers of information (i.e. the Secretary and the Principal) just enough to be able to conduct other diffusion activities. |
| Non-Effective          | This category was used when players did not know the mechanics of the game or the outcome of a specific activity.                                                                                           | For instance, some activities need to be conducted first in order to be able to conduct others -to conduct a Demonstration or a Training Workshop it necessary to talk to the Principal first- Attempting to conduct either of these activities without having talked to the Principal would be a non-effective turn, but players did not know about it. |
| Did Not Know (NE-DK)   |                                                                                                                                                                                                             |                                                                                                                                                                                                |
| Non-Effective          | This category was used when players had failed to pay attention to the feedback or the information provided within the game.                                                                               | For instance, some activities are only effective in specific stages of adoption (e.g. Site Visit is only effective for increasing awareness or interest but not trial/appraisal). Players who continue using Site Visit for attempting to gain points for trial/appraisal have not paid attention to the feedback provided. |
| Did Not Notice (NE-DN) |                                                                                                                                                                                                             |                                                                                                                                                                                                |
Non-Effective Forgot (NE-F) | This category was used when players conducted an activity in spite of having already been aware that it was going to be ineffective. | For instance, some activities are not effective when they are conducted during December or June (within the game’s calendar). A turn in which players conduct those activities during either of those months after players were aware about it from previous turns, was coded as “Forgot”.

Non-Effective Mistake (NE-M) | This category was used when players selected an activity or a staff member different from the one they had intended to select. | For example, if after discussing the next turn both players agree upon conducting an activity with a specific staff member but one of the players accidentally selects a different one, it would be coded as “Mistake”.

The following table summarizes the different APT classifications used in this study along with the categories and the setting in which they were used:

Table 3.14
Summary of APT classifications and categories

<table>
<thead>
<tr>
<th>Classification</th>
<th>Category</th>
<th>Setting</th>
</tr>
</thead>
<tbody>
<tr>
<td>Collaboration level</td>
<td>Negotiation (N)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Passive Negotiation (PN)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Unilateral Decision (U)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Command (C)</td>
<td></td>
</tr>
<tr>
<td>Decider</td>
<td>Player 1 (P1D)</td>
<td>Collaborative</td>
</tr>
<tr>
<td></td>
<td>Player 2 (P2D)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Both (BD)</td>
<td></td>
</tr>
<tr>
<td>Suggestions</td>
<td>Player 1 (P1S)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Player 2 (P2S)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Both (BS)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>None (NS)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>NULL</td>
<td></td>
</tr>
<tr>
<td>Turn Reason</td>
<td>Cognitive (C)</td>
<td>Collaborative</td>
</tr>
<tr>
<td></td>
<td>Exploring (X)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Previous Turn (PT)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Continuing Strategy (CS)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Unknown (U)</td>
<td></td>
</tr>
<tr>
<td>Diffusion Strategy Selection</td>
<td>Effective (E)</td>
<td>Collaborative and Individual</td>
</tr>
<tr>
<td></td>
<td>Non-effective Did Not Know (NE-DK)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Non-effective Did Not Notice (NE-DN)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Non-effective Forgot (NE-F)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Non-effective Mistake (NE-M)</td>
<td></td>
</tr>
</tbody>
</table>
Inter-rater agreement. An IST doctoral candidate assisted the researcher in calculating the inter-rater reliability of the codes for the identified APT categories. The researcher and the other rater coded together several turns from multiple games for two hours in two training sessions. The researcher created the flowchart included in appendix H to facilitate the coding process of the collaboration level APT classification. The flowchart was used in the training sessions to ensure that it was used properly.

The other rater analyzed and coded ten percent of random selected turns independently. On average, the Cohen’s Kappa coefficient across all APT classifications was 0.73. The following table includes the Cohen’s Kappa coefficients for each of the different classifications. As it can be observed each of them fell within the “good agreement” interpretation (Altman, 1991).

Table 3.15
Summary of inter-rater agreement

<table>
<thead>
<tr>
<th>APT Classification</th>
<th>Cohen’s Kappa Coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td>Collaboration level</td>
<td>0.78</td>
</tr>
<tr>
<td>Decider</td>
<td>0.68</td>
</tr>
<tr>
<td>Suggestions</td>
<td>0.84</td>
</tr>
<tr>
<td>Turn Reason</td>
<td>0.64</td>
</tr>
<tr>
<td>Diffusion Strategy Selection</td>
<td>0.71</td>
</tr>
</tbody>
</table>
CHAPTER IV: RESULTS

The data gathered from the various sources described in the previous chapter were analyzed using diverse statistical methods to answer the three research questions that guided this study. Each question is presented below followed by a detailed explanation of the results obtained.

Research Question 1:

Are there any differences in game performance, learning, and attitudes among learners playing an online instructional game individually versus playing it in dyads while following a collaborative script?

The following differences were found after analyzing data from three different data sources (the DSG database, pre- and post- tests, and reactionnaires):

Game Performance – Based on the average scores of their complete games, participants playing in dyads outperformed statistically significantly those playing individually, \( t(31) = 1.711, p = .0485 \) (1-tailed). Moreover, the scores in the dyads were more homogenous, with a range of 2.22 whereas the scores of the individual players were more dispersed, with a range of 4.93. The effect size for this analysis was moderate \( (d = 0.62) \) based on Cohen’s (1988) convention. According to this convention, effect sizes between 0.20 and 0.49 are considered small, between 0.50 and 0.79 are considered medium and higher than 0.80 are considered large (Cohen, 1988).

Learning – Gains in learning was measured by calculating the difference between the post-test and the pre-test scores for each participant. No statistically significant difference was found between participants playing collaboratively and individually, \( t(42) = 1.472, p = .388 \). The mean of gains in learning for participants playing in dyads was
4.1, with a standard deviation of 3.2, whereas it was 3.3 with a standard deviation of 2.8 for those playing individually.

Attitudes – All participants agreed having enjoyed playing the DSG, wanting to play the game more, and considering that playing the DSG was an effective way to learn about the diffusion of innovations theory. On average, all participants had a neutral attitude towards having played the game in the setting assigned. Half of the participants on each setting expressed their preference towards keep playing the DSG in the setting they were originally assigned while the other half expressed their preference towards playing in the opposite setting.

These findings were partially congruent with the researcher’s first hypothesis, which stated:

_Hypothesis 1: Participants in the collaborative setting will outperform participants in the individual setting in terms of game scores and gains in learning._

Participants playing collaboratively did outperform those playing individually only in terms of game scores but not in terms of gains in learning. The following sections elaborate on the analyses conducted to obtain the differences in game performance, learning, and attitudes between participants playing in both settings:

**Game Performance**

As described in the previous chapter, the number of adoption points obtained in the DSG was used as the score to measure game performance. Adoption points is the sum of proportions between the numbers of points obtained per each staff member divided by the total number of actual points needed to get each specific staff member as
an adopter. The maximum number of adoption points that a player can obtain in this version of the game is twelve.

Participants played the DSG multiple times during an 80-minute period, either individually or collaboratively in pairs. Participants were given the freedom to restart playing the game at any time. As shown in Table 4.1, participants assigned to the individual setting played more times on average and completed more games than participants in the collaborative setting. Even though individual participants played more times, they had on average a statistically significant lower score than those playing collaboratively \( t(31) = 1.711, p = .0485 \) (1-tailed). A 1-tailed analysis was used because prior to the study the researcher had already hypothesized, based on the literature in cooperative learning, that participants in the collaborative setting would outperform those in the individual setting.

The following table summarizes the average results obtained from players in both settings:

Table 4.1
*Average game performance in the individual and collaborative settings*

<table>
<thead>
<tr>
<th></th>
<th>Individual setting</th>
<th>Collaborative Setting</th>
</tr>
</thead>
<tbody>
<tr>
<td>Games played on average</td>
<td>8</td>
<td>5</td>
</tr>
<tr>
<td>(Complete and incomplete)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Complete games played on average</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>Adoption Points obtained on average</td>
<td>7.4</td>
<td>8.11</td>
</tr>
</tbody>
</table>
The following table displays the total games played, the complete games played and the adoption points obtained on average across the multiple complete game plays.

Table 4.2
Games played and average adoption points obtained per setting

<table>
<thead>
<tr>
<th>Teams</th>
<th>Total Games Played</th>
<th>Complete Games Played</th>
<th>Average Adoption Points</th>
<th>Indiv.</th>
<th>Total Games Played</th>
<th>Complete Games Played</th>
<th>Average Adoption Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Team_8</td>
<td>4</td>
<td>4</td>
<td>9.15</td>
<td>In_16</td>
<td>4</td>
<td>3</td>
<td>9.24</td>
</tr>
<tr>
<td>Team_4</td>
<td>9</td>
<td>3</td>
<td>8.91</td>
<td>In_11</td>
<td>13</td>
<td>8</td>
<td>9.23</td>
</tr>
<tr>
<td>Team_1</td>
<td>4</td>
<td>3</td>
<td>8.86</td>
<td>In_14</td>
<td>6</td>
<td>2</td>
<td>9.01</td>
</tr>
<tr>
<td>Team_5</td>
<td>4</td>
<td>3</td>
<td>8.66</td>
<td>In_20</td>
<td>14</td>
<td>9</td>
<td>9.01</td>
</tr>
<tr>
<td>Team_2</td>
<td>4</td>
<td>4</td>
<td>8.45</td>
<td>In_2</td>
<td>16</td>
<td>6</td>
<td>8.34</td>
</tr>
<tr>
<td>Team_6</td>
<td>6</td>
<td>3</td>
<td>8.21</td>
<td>In_10</td>
<td>8</td>
<td>8</td>
<td>8.17</td>
</tr>
<tr>
<td>Team_7</td>
<td>7</td>
<td>3</td>
<td>8.00</td>
<td>In_6</td>
<td>11</td>
<td>4</td>
<td>7.89</td>
</tr>
<tr>
<td>Team_9</td>
<td>6</td>
<td>5</td>
<td>7.65</td>
<td>In_7</td>
<td>6</td>
<td>6</td>
<td>7.88</td>
</tr>
<tr>
<td>Team_3</td>
<td>4</td>
<td>4</td>
<td>7.44</td>
<td>In_8</td>
<td>7</td>
<td>4</td>
<td>7.85</td>
</tr>
<tr>
<td>Team_10</td>
<td>6</td>
<td>3</td>
<td>7.00</td>
<td>In_17</td>
<td>8</td>
<td>5</td>
<td>7.77</td>
</tr>
<tr>
<td>Team_11</td>
<td>6</td>
<td>3</td>
<td>6.93</td>
<td>In_18</td>
<td>9</td>
<td>8</td>
<td>7.61</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>In_5</td>
<td>4</td>
<td>3</td>
<td>7.51</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>In_1</td>
<td>5</td>
<td>4</td>
<td>7.39</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>In_3</td>
<td>7</td>
<td>7</td>
<td>7.35</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>In_9</td>
<td>7</td>
<td>3</td>
<td>7.19</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>In_19</td>
<td>7</td>
<td>2</td>
<td>6.94</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>In_21</td>
<td>8</td>
<td>7</td>
<td>6.48</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>In_12</td>
<td>8</td>
<td>5</td>
<td>6.36</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>In_15</td>
<td>14</td>
<td>11</td>
<td>6.21</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>In_4</td>
<td>7</td>
<td>7</td>
<td>6.10</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>In_13</td>
<td>10</td>
<td>6</td>
<td>5.01</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>In_22</td>
<td>6</td>
<td>4</td>
<td>4.31</td>
</tr>
</tbody>
</table>

In can be observed in Table 4.2 that the range of average scores in the individual setting was more than double than those in the collaborative setting (4.93 and 2.22, respectively). This difference indicated that the game performance of those playing collaboratively was in general more consistent or uniform whereas it had a greater variation in participants who played individually. It can also be observed that there were two individual players who obtained an average score higher than the highest-score dyad. On the other hand, there were six individual players with an average score lower than the lowest-score dyad.
Is gender an issue? Since males typically play more video games than females, the question arose as to whether gender might have some effect on game performance when playing the DSG in this study. To investigate this, first the relation between game setting and gender was examined. It can be seen in Table 4.3 that gender was not evenly distributed in the two settings. There were more females than males in the individual setting (15 vs. 7), and in the collaborative setting, there were more males than females (13 vs. 9). The obtained chi-square value was 3.3 ($df = 1$) and approached statistical significance ($p = 0.069$). This raised the question of whether gender might explain the difference in performance in the individual and collaborative settings, rather than the setting itself. While participants were randomly assigned to each setting, there was nonetheless gender imbalance. Gender was not considered as a stratifying variable during the random assignment process.

Table 4.3

<table>
<thead>
<tr>
<th>Gender</th>
<th>Setting</th>
<th>( \text{Female} )</th>
<th>( \text{Male} )</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Individual</td>
<td>15</td>
<td>7</td>
<td>22</td>
</tr>
<tr>
<td></td>
<td>Team</td>
<td>9</td>
<td>13</td>
<td>22</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>24</strong></td>
<td><strong>20</strong></td>
<td><strong>44</strong></td>
</tr>
</tbody>
</table>

Males in this study played games significantly more hours per week than females. An ANOVA revealed that the difference was highly significant ($p = 0.003$). Males played games an average of 2.9 hours per week ($SD = 3.03$), whereas females played an average of 0.79 hours per week ($SD = 1.21$).

Therefore, an analysis of covariance was run to control statistically for gender and prior gameplay experience. Results of ANCOVA indicated that collaborative dyads still
outperformed the individuals \((F = 3.46, df = 1.42, p = 0.035 \text{ (1-tailed)})\). It appears that gender and prior game experience were not the reasons that participants in the collaborative game setting performed better than those in the individual setting on the average number of adoptions points earned when playing the DSG repeatedly.

**Performance in Best Games**

In addition to using the average scores across all games to examine the difference in performance between both settings, the game in which they had obtained the highest score was also analyzed. Comparing their performance using their best games was done to account for the possibility of participants having made intentional mistakes in some games while exploring how to play. The following table shows the scores obtained in their best game and the time, in minutes, they lasted.

**Table 4.4**

*Score from each players' best games and time taken to complete it*

<table>
<thead>
<tr>
<th>Teams</th>
<th>Adoption Points</th>
<th>Time (min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Team 1</td>
<td>10.99</td>
<td>9</td>
</tr>
<tr>
<td>Team 9</td>
<td>10.82</td>
<td>8</td>
</tr>
<tr>
<td>Team 8</td>
<td>10.22</td>
<td>18</td>
</tr>
<tr>
<td>Team 7</td>
<td>10.11</td>
<td>15</td>
</tr>
<tr>
<td>Team 2</td>
<td>10.00</td>
<td>9</td>
</tr>
<tr>
<td>Team 5</td>
<td>9.83</td>
<td>13</td>
</tr>
<tr>
<td>Team 4</td>
<td>9.75</td>
<td>13</td>
</tr>
<tr>
<td>Team 3</td>
<td>9.35</td>
<td>12</td>
</tr>
<tr>
<td>Team 10</td>
<td>8.94</td>
<td>19</td>
</tr>
<tr>
<td>Team 6</td>
<td>8.65</td>
<td>20</td>
</tr>
<tr>
<td>Team 11</td>
<td>7.23</td>
<td>11</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Individuals</th>
<th>Adoption Points</th>
<th>Time (min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>In 16</td>
<td>12</td>
<td>9</td>
</tr>
<tr>
<td>In 11</td>
<td>11.78</td>
<td>6</td>
</tr>
<tr>
<td>In 2</td>
<td>11.71</td>
<td>7</td>
</tr>
<tr>
<td>In 20</td>
<td>11</td>
<td>6</td>
</tr>
<tr>
<td>In 10</td>
<td>10.18</td>
<td>9</td>
</tr>
<tr>
<td>In 6</td>
<td>9.55</td>
<td>6</td>
</tr>
<tr>
<td>In 8</td>
<td>9.43</td>
<td>12</td>
</tr>
<tr>
<td>In 5</td>
<td>9.37</td>
<td>8</td>
</tr>
<tr>
<td>In 3</td>
<td>9.24</td>
<td>8</td>
</tr>
<tr>
<td>In 1</td>
<td>9.02</td>
<td>9</td>
</tr>
<tr>
<td>In 14</td>
<td>8.96</td>
<td>8</td>
</tr>
<tr>
<td>In 7</td>
<td>8.94</td>
<td>10</td>
</tr>
<tr>
<td>In 9</td>
<td>8.72</td>
<td>8</td>
</tr>
<tr>
<td>In 18</td>
<td>8.63</td>
<td>7</td>
</tr>
<tr>
<td>In 19</td>
<td>8.06</td>
<td>8</td>
</tr>
<tr>
<td>In 17</td>
<td>7.95</td>
<td>9</td>
</tr>
<tr>
<td>In 21</td>
<td>7.95</td>
<td>10</td>
</tr>
<tr>
<td>In 12</td>
<td>7.65</td>
<td>15</td>
</tr>
<tr>
<td>In 15</td>
<td>7.38</td>
<td>4</td>
</tr>
<tr>
<td>In 4</td>
<td>6.88</td>
<td>8</td>
</tr>
</tbody>
</table>
The lowest scores from each setting (7.23 and 4.81) were identified as outliers thus they were removed to normalize the distribution for conducting an independent samples t-test. The score of participants in the collaborative setting was once again higher than those in the individual setting: $t(29) = 1.589, p = 0.026$ (1-tailed). The effect size for this analysis was moderate ($d = 0.60$) based on Cohen’s (1988) convention. Moreover, the difference of range of scores between their best games was almost double (3.76 and 7.19, respectively), indicating once again a higher consistency in the scores in the collaborative setting.

A deeper analysis of the average scores (Table 4.2) and the scores from their best games (Table 4.3), shows that both lists of scores are statistically significantly correlated, $r = 0.867, p < 0.0001, n = 33$. This correlation indicates that, in general, players who obtained a high or low score on average across all games also obtained a high or low score in their best game. Regarding the amount of time taken to complete their best game, on average, participants in the collaborative setting took 60% longer than players in the individual setting.

To determine whether gender and game experience might have affected best game performance, an ANCOVA was run to control statistically by using these two variables as covariates. Results indicated that the mean best game performance for participants in the collaborative setting was significantly greater than the mean for participants in the individual setting ($F = 3.95, df = 1.39, p = 0.027$ (1-tailed)).

Learning
Learning gains concerning the diffusion of innovations theory from playing the DSG were measured using a 15-item instrument which was administered as a pre-test on the day each participant was randomly assigned to the individual or collaborative setting and as a post-test on the day participants completed playing the DSG.

In order to stimulate the participants to learn from playing the game and for giving their best effort when taking the post-test, the researcher had informed them, prior to starting, about the possibility to participate in two $50 dollar raffles and that their participation eligibility was based on their combined performance playing the game and taking the test. The test included items that measured both conceptual and procedural knowledge related to the diffusion of innovations theory, which participants were unfamiliar prior to playing the DSG. Participants did not receive any additional instructional material or information related to this theory.

Fourteen out of the 15 items included in the post-test were answered correctly by at least half of all the participants, whereas the remaining item was answered correctly by 40% of them. Gains in learning were measured as the difference between the scores in the post-test and the pre-test. Cronbach’s alpha internal consistency reliability of the test was 0.690 including all 15 items. After removing item 9, alpha increased to 0.709.

In both settings, the participants’ gains in learning improved in a statistically significantly manner after the 80-minute game session. For the individual setting, the improvement went from a mean of 6.18 and a standard deviation of 2.03 on the pre-test to a mean of 9.47 and a standard deviation of 2.26 on the post-test, with a paired-sample test value of \( t(21) = 5.342, p < 0.0001 \). The improvement was slightly greater for the participants in the collaborative setting, from a mean of 5.78, standard deviation of 2.21
on the pre-test to a mean of 9.92, standard deviation of 2.34 on the post-test, $t(21) = 5.867, p < 0.00001$.

While these results indicated that participants did learn significantly about the diffusion of innovations theory by playing the DSG, the difference of improvement between both settings was not statistically significant, $t(42) = 1.707, p = 0.364$.

The following table includes the pre- and post-test scores from both settings.

Table 4.5

Pre- and Post-test scores by participants from both settings

<table>
<thead>
<tr>
<th>Collaborative Setting</th>
<th>Student Id</th>
<th>Pre-Test</th>
<th>Post-Test</th>
<th>Post-Pre</th>
</tr>
</thead>
<tbody>
<tr>
<td>team1a</td>
<td>6</td>
<td>8.99</td>
<td>2.99</td>
<td></td>
</tr>
<tr>
<td>team1b</td>
<td>5</td>
<td>9.99</td>
<td>4.99</td>
<td></td>
</tr>
<tr>
<td>team2a</td>
<td>8.33</td>
<td>10.33</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>team2b</td>
<td>4.33</td>
<td>11.66</td>
<td>7.33</td>
<td></td>
</tr>
<tr>
<td>team3a</td>
<td>8.33</td>
<td>7.66</td>
<td>-0.67</td>
<td></td>
</tr>
<tr>
<td>team3b</td>
<td>2.99</td>
<td>9</td>
<td>6.01</td>
<td></td>
</tr>
<tr>
<td>team4a</td>
<td>4.33</td>
<td>8.66</td>
<td>4.33</td>
<td></td>
</tr>
<tr>
<td>team4b</td>
<td>4.66</td>
<td>12.66</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>team5a</td>
<td>8.32</td>
<td>10</td>
<td>1.68</td>
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</tr>
<tr>
<td>team5b</td>
<td>9.32</td>
<td>11.66</td>
<td>2.34</td>
<td></td>
</tr>
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<td>team6a</td>
<td>3.33</td>
<td>12.66</td>
<td>9.33</td>
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</tr>
<tr>
<td>team6b</td>
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<td>7.66</td>
<td>2</td>
<td></td>
</tr>
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<td>team7a</td>
<td>8</td>
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<td>-1.34</td>
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<td>team7b</td>
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<td>10.66</td>
<td>8.66</td>
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</tr>
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<td>4.66</td>
<td>13.33</td>
<td>8.67</td>
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</tr>
<tr>
<td>team8b</td>
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<td>6</td>
<td>0.67</td>
<td></td>
</tr>
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</tr>
<tr>
<td>team9b</td>
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<td>13.66</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>team10a</td>
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<td>-1</td>
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</tr>
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<td>team10b</td>
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<td>11.66</td>
<td>5.34</td>
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</tr>
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<td>team11a</td>
<td>4.33</td>
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<td>6.67</td>
<td></td>
</tr>
<tr>
<td>team11b</td>
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<td>8.33</td>
<td>5</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Individual Setting</th>
<th>Student Id</th>
<th>Pre-Test</th>
<th>Post-Test</th>
<th>Post-Pre</th>
</tr>
</thead>
<tbody>
<tr>
<td>in 1</td>
<td>7.66</td>
<td>7</td>
<td>-0.66</td>
<td></td>
</tr>
<tr>
<td>in 2</td>
<td>4.99</td>
<td>10.66</td>
<td>5.67</td>
<td></td>
</tr>
<tr>
<td>in 3</td>
<td>3.99</td>
<td>6.33</td>
<td>2.34</td>
<td></td>
</tr>
<tr>
<td>in 4</td>
<td>9.32</td>
<td>6.99</td>
<td>-2.33</td>
<td></td>
</tr>
<tr>
<td>in 5</td>
<td>7.33</td>
<td>12.66</td>
<td>5.33</td>
<td></td>
</tr>
<tr>
<td>in 6</td>
<td>7.99</td>
<td>6.66</td>
<td>-1.33</td>
<td></td>
</tr>
<tr>
<td>in 7</td>
<td>4</td>
<td>10.33</td>
<td>6.33</td>
<td></td>
</tr>
<tr>
<td>in 8</td>
<td>6.33</td>
<td>9.66</td>
<td>3.33</td>
<td></td>
</tr>
<tr>
<td>in 9</td>
<td>4.66</td>
<td>14</td>
<td>9.34</td>
<td></td>
</tr>
<tr>
<td>in 10</td>
<td>6.66</td>
<td>9.33</td>
<td>2.67</td>
<td></td>
</tr>
<tr>
<td>in 11</td>
<td>3.66</td>
<td>9.33</td>
<td>5.67</td>
<td></td>
</tr>
<tr>
<td>in 12</td>
<td>3</td>
<td>5.99</td>
<td>2.99</td>
<td></td>
</tr>
<tr>
<td>in 13</td>
<td>3.99</td>
<td>8</td>
<td>4.01</td>
<td></td>
</tr>
<tr>
<td>in 14</td>
<td>10.99</td>
<td>10</td>
<td>-0.99</td>
<td></td>
</tr>
<tr>
<td>in 15</td>
<td>5.99</td>
<td>8.66</td>
<td>2.67</td>
<td></td>
</tr>
<tr>
<td>in 16</td>
<td>6.33</td>
<td>7</td>
<td>0.67</td>
<td></td>
</tr>
<tr>
<td>in 17</td>
<td>7.99</td>
<td>10.66</td>
<td>2.67</td>
<td></td>
</tr>
<tr>
<td>in 18</td>
<td>7.33</td>
<td>12.33</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>in 19</td>
<td>5.66</td>
<td>9.33</td>
<td>3.67</td>
<td></td>
</tr>
<tr>
<td>in 20</td>
<td>5.66</td>
<td>12.33</td>
<td>6.67</td>
<td></td>
</tr>
<tr>
<td>in 21</td>
<td>4.33</td>
<td>9.33</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>in 22</td>
<td>7.99</td>
<td>11.66</td>
<td>3.67</td>
<td></td>
</tr>
</tbody>
</table>

Since gender and game experience also might have affected learning gains, similar to concerns about DSG performance, a repeated measures analysis was performed with the SPSS 19 General Linear Model (GLM) procedure. The within-subjects factor
was the test occasion (pre- and posttest scores), the independent variable was the game setting (individuals vs. collaborative dyads), and the covariates were gender (F, M) and prior game experience (hours per week). The difference in test occasion means remained highly significantly different ($p < 0.0005$). The adjusted posttest mean was significantly higher than the pretest mean. The interaction between test occasion and gender was also statistically significant ($p < 0.024$), whereas game experience and game setting were not significant at $p < 0.05$. On average, females made greater gains in learning than did males when playing the DSG. Since there were fewer females in the collaborative settings, this may have confounded the relationship with setting and learning achievement.

While the relationship between gender and learning gains was not significant in the univariate ANOVA, the increase in precision of the ANCOVA reduced the error variance enough for the F ratio to reach significance. On the other hand, when using gender and prior game experience as covariates, this did not reduce the error variance enough for the game setting (cooperative dyads vs. individuals) to reach significance in predicting learning gains from pre- to posttest.

**Attitudes**

Participants’ attitudes towards their learning experience were measured by a reactionnaire that included several Likert scale items and an open-ended question. The Likert items were divided into two sets. The first set consisted of six items measuring the participants’ level of enjoyment playing the DSG whereas the second set of items was used to measure the extent participants liked playing in the setting they were assigned, either individual or collaborative.
On average, regardless of the setting they were assigned, most participants agreed having enjoyed playing the game, wanting to play more, and considered that playing the game was an effective way to learn. The following table summarizes the participants’ responses towards their level of enjoyment playing the game.

Table 4.6
*Participants attitudes towards playing the DSG*

<table>
<thead>
<tr>
<th></th>
<th>Individual</th>
<th></th>
<th>Collaborative</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>St. Dev.</td>
<td>Mean</td>
<td>St. Dev.</td>
</tr>
<tr>
<td>I enjoyed playing the game.</td>
<td>3.95</td>
<td>0.78</td>
<td>4.18</td>
<td>0.59</td>
</tr>
<tr>
<td>The game does not reflect reality.</td>
<td>2.22</td>
<td>0.87</td>
<td>2.18</td>
<td>0.5</td>
</tr>
<tr>
<td>If given the chance, I would like to play the game more.</td>
<td>3.9</td>
<td>1.02</td>
<td>3.82</td>
<td>1</td>
</tr>
<tr>
<td>I think playing the game was an effective way to learn.</td>
<td>4.09</td>
<td>0.97</td>
<td>4.05</td>
<td>0.84</td>
</tr>
</tbody>
</table>

A scale measuring the level of enjoyment playing the game was created using the four items in the table above. Cronbach’s alpha reliability of this scale was 0.805. On average, individual participants agreed having enjoyed playing the DSG (mean = 3.93, standard deviation = 0.74) and so did the participants in the collaborative setting (mean = 3.96, standard deviation = 0.58).

In order to measure participants’ attitudes towards having played individually or collaboratively, a slightly different set of Likert-type items was provided to each setting. For instance, for participants playing collaboratively, one of the items read: “I felt more motivated playing the DSG as part of a team than if I had played alone”, whereas for participants playing individually, the corresponding item read: “I feel that I would have been more motivated playing this game with somebody else instead of playing it alone.” Some of these items were adapted from an attitudinal survey used by Brewer and Klein (2006).
On average, participants in both settings had a neutral attitude towards having played in the setting assigned. For the individual setting, the scale mean was 2.82 and the standard deviation was 0.97, whereas for the collaborative setting the scale mean was 3.4 and the standard deviation was 0.94. In addition to the Likert items, all participants answered an open-ended question in which they expressed the reasons why they preferred playing the game either individually or with someone else. From the twenty participants in the collaborative setting who submitted the reactionnaire, half of them expressed their preference to playing the game individually while the other half preferred playing the game with someone else.

Some of the comments from those who played collaboratively expressing their preferences for this setting were: “Overall, I would prefer playing with a team even if we disagreed.” and “I definitely don't think I would have been able to get so many adopters without my teammate.” While some of the comments expressing their preference for playing individually were: “I would prefer playing the game individually because that way I will feel more comfortable making decisions.” and “If I played individually, I would be able to play it more quickly and have more tries to get to the eight adopter goal”.

In general, some of the reasons participants playing collaboratively wanted to keep playing in this way were that a) they were able to generate more ideas, b) they felt more motivated, and c) they were able to solve more problems by identifying issues. The two main reasons why participants who played in a team wanted to play individually were a) needing more time to complete games in a team, and b) having less control when
Research Question 2

How do personality traits correspond with performance, learning, and attitude in students playing an online instructional game in both settings (individually and collaboratively)?

Participants’ personality traits were identified using John’s (2008) Big Five Inventory (see appendix D), which consists of 44 Likert-scale items that measure personality traits according to the Big Five model (Costa & McCrae, 1985). The following table summarizes the personality traits that were related to participants’ game performance, gains in learning and attitudes towards having played in the setting assigned. These relationships are described in the following sections.

Table 4.7
Correlation between personality traits and performance and attitudes

<table>
<thead>
<tr>
<th>Setting</th>
<th>Individual</th>
<th>Collaborative</th>
</tr>
</thead>
<tbody>
<tr>
<td>Personality Traits</td>
<td>Correlation Coefficient</td>
<td>Personality Traits</td>
</tr>
<tr>
<td>Game Performance</td>
<td>Conscientiousness</td>
<td>$r = 0.390, p = .073$</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gains in Learning</td>
<td>Extraversion</td>
<td>$r = -.478, p = .025$</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Attitudes</td>
<td>Agreeableness</td>
<td>$r = -.421, p = .051$</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Personality Traits and Game Performance

In order to measure the relationship between the personality traits and the participants’ game performances, several bivariate correlation analyses were conducted between each of the personality traits and the average score across all complete game plays per individual participant or dyad.

Since the conscientiousness trait, which refers to the individual’s level of responsibility, reliability, thoroughness, and persistence, has been found correlated to tasks performance (Barrick & Mount, 1991; Bell, 2007; Kichuk & Wiesner, 1997; Tett, Jackson, Rothstein, & Reddon, 1994), the following hypothesis had been posited:

_Hypothesis 2: Conscientiousness will be related to the game performance in the individual setting._

As shown on Table 4.6, in the individual setting, the only personality trait that was related to game performance was conscientiousness, and this relation was marginally significant (r = 0.390, p = 0.073, n = 22). This result was aligned with the literature of personality psychology in the sense that people who perceived themselves as highly responsible, reliable, and tenacious are associated with improved task performance.

In the collaborative setting, participants were paired off based on a similar level of agreeableness. Since this personality trait, which refers to the individual’s level of being polite, tolerant, trustful, and willing to cooperate (Barrick & Mount, 1991), has also been related to group task performance (Bell, 2007), the following hypothesis had being put forward:

_Hypothesis 3: Agreeableness will be related to the game performance in the collaborative setting._
Contrary to this hypothesis, participants’ levels of agreeableness were negatively correlated with their game performance ($r = -0.411, p = 0.058, n = 22$). This indicated that teams in which both students perceived themselves as highly polite, tolerant, and trustful had the lowest scores. As it will be described in pattern analysis discussion below, teams which exhibited more patterns of discussion, disagreement and exchange of ideas obtained higher scores.

An unexpected finding from the collaborative setting was that the participants’ level of extraversion, which refers to the level of sociability, gregariousness, and talkativeness was also negatively correlated to their game performance ($r = -0.459, p = 0.032, n = 22$). This finding was unexpected because the dyads formation did not control for this personality trait. This finding indicated that dyads with a higher level of extraversion obtained lower game scores than dyads with a lower level of extraversion.

**Personality Traits and Learning Gains**

Regarding the relationship between personality traits and learning gains, participants in the individual setting exhibited a statistically significant negative correlation between their level of extraversion and the gains in learning measured by the difference between their scores in the pre- and post- tests ($r = -0.478, p = 0.025, n = 22$). This negative significant correlation was also observed between their level of extraversion and the results from the post-test ($r = -0.422, p = 0.051, n = 22$). These results indicated that participants who perceived themselves as quiet and reserved tended to make greater gains in learning, regardless of their game performance. No other personality trait was significantly correlated with individual participants’ learning.
For participants in the collaborative setting, there were two personality traits that were marginally significantly correlated to their learning gains: conscientiousness ($r = 0.37, p = 0.09, n = 22$), and openness to experience ($r = 0.39, p = 0.073, n = 22$). This result indicated that those participants who perceived themselves as more responsible, reliable, and creative obtained higher gains in learning.

**Personality Traits and Attitudes**

As explained in the previous research question, a scale was calculated with the participants’ attitudes towards having played the game either individually or collaboratively. The correlation between the attitudinal scale and the participants’ personality traits was then investigated. The following table summarizes these correlations.

Table 4.8
*Correlation between personality traits and attitudes towards playing in the setting assigned*

<table>
<thead>
<tr>
<th>Personality Trait</th>
<th>Attitudes towards playing in teams</th>
<th>Attitudes towards playing individually</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extraversion</td>
<td>Correlation Coefficient: 0.567</td>
<td>Correlation Coefficient: -0.015</td>
</tr>
<tr>
<td></td>
<td>Sig.: 0.006</td>
<td>Sig.: 0.949</td>
</tr>
<tr>
<td>Agreeableness</td>
<td>Correlation Coefficient: -0.153</td>
<td>Correlation Coefficient: -0.421</td>
</tr>
<tr>
<td></td>
<td>Sig.: 0.496</td>
<td>Sig.: 0.051</td>
</tr>
<tr>
<td>Conscientiousness</td>
<td>Correlation Coefficient: -0.099</td>
<td>Correlation Coefficient: -0.144</td>
</tr>
<tr>
<td></td>
<td>Sig.: 0.661</td>
<td>Sig.: 0.523</td>
</tr>
<tr>
<td>Neuroticism</td>
<td>Correlation Coefficient: 0.466</td>
<td>Correlation Coefficient: 0.060</td>
</tr>
<tr>
<td></td>
<td>Sig.: 0.029</td>
<td>Sig.: 0.790</td>
</tr>
<tr>
<td>Openness</td>
<td>Correlation Coefficient: 0.002</td>
<td>Correlation Coefficient: -0.129</td>
</tr>
<tr>
<td></td>
<td>Sig.: 0.992</td>
<td>Sig.: 0.567</td>
</tr>
</tbody>
</table>

Since the level of extraversion refers to the extent to which a person enjoys socializing with others (Barrick & Mount, 1991), it was hypothesized that this personality
trait would be correlated to the participants’ preference towards a specific setting in the following way:

Hypothesis 4: Participants’ attitudes towards having played in the setting assigned will be correlated to their level of extraversion: extroverts will express their preference for continuing playing collaboratively while introverts will prefer playing individually.

As it can be observed in the table above, in the team setting there was a significant correlation between their preference towards having played the game collaboratively and their level of extraversion \((r = 0.567, p = 0.006, n = 22)\). Their correlation with the level of neuroticism approached statistical significance \((r = 0.418, p = 0.053, n = 22)\). This result indicated that those participants who perceived themselves as highly sociable, talkative, and emotionally stable preferred playing the game with a partner. No significant correlation was found with the remaining personality traits.

In the individual setting, the only personality trait that was statistically correlated to the participants’ attitudes toward having played the game individually was their level of agreeableness \((r = -0.421, p = 0.051, n = 22)\). This result indicated that participants who did not consider themselves very cooperative and supportive to others, preferred playing the game alone.
Research Question 3

What are the main pattern differences between the games with the highest and lowest scores? Are there any common patterns in the game play strategies used by students within each setting (individual or collaborative)?

This research question was aimed at investigating potential differences in patterns of strategies that might have contributed to some participants performing better at playing the DSG than others. There were actually two questions addressed. The first one explored the differences between the games with the highest and lowest scores, regardless of the setting assigned whereas the second question examined the differences within each setting.

In order to answer both questions, the researcher transcribed and analyzed the screencast recordings of all the game sessions of the players with the top two, middle two, and lowest two average game scores, as measured by the number of adoption points obtained, per setting. The following table includes the number of games they played (they were able to play as many games as desired without having to complete a game to start a new one), the number of complete games, their average number of adopters, their average scores obtained across multiple complete game sessions, and their highest and lowest scores.

Table 4.9
Players with the highest, middle, and lowest average game scores

<table>
<thead>
<tr>
<th>Player(s)</th>
<th>Total Games Played</th>
<th>Complete Games</th>
<th>Avg. Adopters</th>
<th>Avg. Score</th>
<th>Best Game Score</th>
<th>Worst Game Score</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Top 2 Teams</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Team 8</td>
<td>4</td>
<td>4</td>
<td>5</td>
<td>9.15</td>
<td>10.22</td>
<td>7.16</td>
</tr>
<tr>
<td>Team 4</td>
<td>9</td>
<td>3</td>
<td>5</td>
<td>8.91</td>
<td>9.75</td>
<td>8.43</td>
</tr>
<tr>
<td><strong>Middle 2 Teams</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Team 2</td>
<td>4</td>
<td>4</td>
<td>6</td>
<td>8.45</td>
<td>10</td>
<td>7.24</td>
</tr>
<tr>
<td>Team 6</td>
<td>6</td>
<td>3</td>
<td>4</td>
<td>8.21</td>
<td>8.65</td>
<td>7.57</td>
</tr>
</tbody>
</table>
As explained in the previous chapter, Analysis of Patterns in Time (APT) was used to address these questions. There were three APT analyses conducted. The first one compared patterns between the games with the highest and lowest scores in both settings, the second one identified patterns between the dyads who had obtained the highest and lowest average scores, and the third one identified patterns between the individual players with the highest and lowest average scores. The following sections explain each of the APT analyses conducted.

**Patterns in the Games with the Highest and Lowest Scores**

The first APT analysis consisted of comparing the type and number of effective turns between the best and worst games played by participants from both settings. In the DSG, a turn consists of a player: (1) selecting a diffusion or an information activity, (2) selecting up to three staff members, if the activity requires it, and (3) clicking on the “Conduct Activity” button. A turn also incurs an associated cost of one to three weeks out of the total 36 weeks available in the game. The number of turns varied per game.
depending on the costs of the activities selected, but on average there were 25 turns per complete game. The effectiveness of a turn was determined based on an adaptation of a set of strategies identified by Myers (2012) that, being aligned with the diffusion of innovations theory, are effective to obtaining a high score in the DSG. In this regard, the following hypothesis was stated:

**Hypothesis 5:** Games with the highest scores will use strategies that are aligned with the diffusion of innovations theory more often than games with the lowest scores.

In the DSG, an effective strategy involves conducting an activity (e.g., *Presentation, Talk to, Pilot Test, Demonstration*) with the most appropriate staff members and at the right time. For example, one of the activities that players can conduct is a *Demonstration*, which consists of inviting all staff members into the classroom of a teacher who has already adopted the innovation, to see it in action. According to the list of effective strategies, a *Demonstration* is considered to be effective strategy only if the teacher who is selected for conducting it is an opinion leader; however, since in the DSG the Principal is a gatekeeper of information, conducting a *Demonstration* with an opinion leader would not be effective without having approached him first. Yet, another factor to consider is that, since a *Demonstration* is only effective for raising points in the *Interest* phase, it would not be considered effective if most of the staff members have not reached or have moved beyond that specific phase.

The following table shows all of the activities conducted in the best game of team 10. In APT terminology, the following table represents a temporal map with 24 APT events (as represented for a DSG turn in this specific context). Specific patterns may be counted within a temporal map, resulting in a frequency of such event patterns. Each row
in Table 4.9 represents an APT joint event, where a category from each classification
characterizes what occurred on that turn. The last column shows the joint occurrences of
having conducted a *Demonstration* activity effectively.

**Table 4.10**

*Illustration of APT counting for the joint occurrence of a Demonstration activity and its Effectiveness (in the far right column). The first 6 columns represent the temporal map for Team 10’s best game. The 7th column represents hits and misses for the APT Query for the joint event (hit = 1; miss = 0).*

<table>
<thead>
<tr>
<th>Player</th>
<th>Turn</th>
<th>Week</th>
<th>Activity</th>
<th>Staff Selected</th>
<th>Diffusion Strategy Selection</th>
<th>Frequency of Joint Occurrence of Demonstration &amp; Effectiveness Categories</th>
</tr>
</thead>
<tbody>
<tr>
<td>Team 10</td>
<td>1</td>
<td>2</td>
<td>Presentation</td>
<td>NULL</td>
<td>E</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>3</td>
<td>Personal Info</td>
<td>A,B,C</td>
<td>E</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>4</td>
<td>Personal Info</td>
<td>D,E,F</td>
<td>E</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>5</td>
<td>Personal Info</td>
<td>G,H,I</td>
<td>E</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>6</td>
<td>Talk to</td>
<td>G</td>
<td>E</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>7</td>
<td>Talk to</td>
<td>C</td>
<td>E</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>8</td>
<td>Talk to</td>
<td>F</td>
<td>E</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>8</td>
<td>9</td>
<td>Talk to</td>
<td>E</td>
<td>NE-F</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>9</td>
<td>10</td>
<td>Talk to</td>
<td>F</td>
<td>E</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>12</td>
<td>Pilot Test</td>
<td>F</td>
<td>E</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>11</td>
<td>13</td>
<td>Demonstration</td>
<td>F</td>
<td>NE-F</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>12</td>
<td>14</td>
<td>Talk to</td>
<td>B</td>
<td>E</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>13</td>
<td>15</td>
<td>Talk to</td>
<td>A</td>
<td>E</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>14</td>
<td>16</td>
<td>Talk to</td>
<td>B</td>
<td>NE-DN</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>15</td>
<td>17</td>
<td>Talk to</td>
<td>A</td>
<td>NE-DN</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>16</td>
<td>19</td>
<td>Pilot Test</td>
<td>C</td>
<td>E</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>17</td>
<td>20</td>
<td>Talk to</td>
<td>A</td>
<td>NE-DN</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>18</td>
<td>23</td>
<td>Demonstration</td>
<td>F</td>
<td>E</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>19</td>
<td>26</td>
<td>Training Workshop</td>
<td>NULL</td>
<td>E</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>20</td>
<td>28</td>
<td>Pilot Test</td>
<td>H</td>
<td>E</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>21</td>
<td>29</td>
<td>Talk to</td>
<td>E</td>
<td>NE-F</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>22</td>
<td>30</td>
<td>Talk to</td>
<td>D</td>
<td>NE-F</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>23</td>
<td>32</td>
<td>Site Visit</td>
<td>A,D,E</td>
<td>NE-DN</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>24</td>
<td>36</td>
<td>Demonstration</td>
<td>H</td>
<td>NE-DN</td>
<td>0</td>
</tr>
</tbody>
</table>
As it can be observed on the table above, team 10 conducted three Demonstrations in this game (in turns 11, 18, and 24). The code of the Diffusion Strategy Selection category assigned was Non effective-Forgot (NE-F) because players had forgotten that they needed to Talk to the Principal (coded with the letter A) prior to attempting the Demonstration. Their third Demonstration was ineffective too; this time the code of the Diffusion Strategy Selection category was Non effective-Did not Notice (NE-DN) because players failed to notice that there were no staff members in the Interest phase and none of them benefitted from this activity. Thus the only joint occurrence of having conducted a Demonstration activity that was Effective (E) was in turn 18, as marked by the number one in the last column. In APT, the relative frequency of an event pattern is a proportion, which is the number of events divided by the total number of relevant events within a temporal map. Since team 10 conducted only one Demonstration activity effectively and there were 24 turns in their best game, the proportion of conducting a Demonstration effectively was $1/24 = .042^1$.

The joint occurrences were calculated using formulas in Microsoft Excel. For instance, supposing that the first column in the following table was A, the Excel formula to calculate whether the Demonstration activity was effective would be:

=IF(AND($D2="Demonstration",$F2="E"),1, 0)

Some of these Excel formulas included more than one activity and one staff member. For instance, the following formula was used to count the joint occurrences of having conducted either a Talk to or a Pilot Test activity effectively with either the Math Teacher (F) or the Science Teacher (H), who are the opinion leaders.

---

1 A more informative analysis consists of using conditional probability instead of joint probability (cf. Frick, 1990; cf. Frick, Chadha, Watson, Wang, & Green, 2009). However, conditional probability can always be calculated based on the joint probability values.
Using once again the data included in Table 4.19, it can be observed that a Talk to or a Pilot Test activity was conducted effectively with either the Math Teacher (F) or the Science teacher (H) four times (in turns 7, 9, 10, and 20), thus having a proportion of $4/24 = 0.17$. Similar analyses were conducted for each of the identified effective strategies for all the best and worst games of the sample of players listed previously in Table 4.8. The resulted proportions were then averaged across temporal maps to create mean proportions and their respective standard deviations.

As expected, the best games exhibited a greater number of effective strategies than the worst games. The following table summarizes the percentages of the four effective strategies that were conducted significantly more often in the best games than in the worst ones.

<table>
<thead>
<tr>
<th>BEST GAMES</th>
<th>Talk/Pilot/SV Opinion Leader &amp; Effective</th>
<th>Demonstration &amp; Effective</th>
<th>Training Workshop &amp; Effective</th>
<th>Blog &amp; Effective</th>
</tr>
</thead>
<tbody>
<tr>
<td>Individual Players</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ind17</td>
<td>0.200</td>
<td>0.040</td>
<td>0.120</td>
<td>0.000</td>
</tr>
<tr>
<td>Ind12</td>
<td>0.208</td>
<td>0.083</td>
<td>0.083</td>
<td>0.042</td>
</tr>
<tr>
<td>Ind6</td>
<td>0.174</td>
<td>0.043</td>
<td>0.087</td>
<td>0.043</td>
</tr>
<tr>
<td>Ind18</td>
<td>0.308</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
</tr>
</tbody>
</table>
As it can be observed in Table 4.10, the mean proportion of conducting a *Training Workshop* effectively in the best games was 0.053 as opposed of not having conducted this activity at all in the worst games. It can also be seen that the mean proportion of conducting a *Demonstration* effectively was 0.039 for the best games, whereas it was 0.017 for the worst games. In other words, participants were more than twice as likely to conduct a *Demonstration* activity effectively in their best game (0.039/0.017 = 2.29). There was a statistically significant difference in the frequency these two activities were
conducted in the best and worst games: \( t(11) = 4.44, p = 0.001 \) for *Training Workshop* and \( t(11) = 2.597, p = 0.025 \) for *Demonstration*. In terms of points awarded, both of these activities are the most powerful because if staff members are in the right phase when either of these activities is conducted, players could get up to 20 points in just one turn. In contrast, in most of the other activities, players can get up to eight points.

Another relevant difference between the best and worst games is the number of strategies in which players targeted opinion leaders. In their best games, players targeted opinion leaders 0.5 times more than in their worst games. This activity is also very important because *Demonstrations* are only effective when conducted by opinion leaders who have already adopted the innovation, thus more an opinion leader is targeted, the more likely it is to get him/her as an adopter. There was also a statistically significant difference between the frequency opinion leaders were targeted in the best and the worst games (\( t(11) = 2.367, p = 0.037 \)). In addition, players were more likely to conduct three times more *Blog Post* activities effectively in the best games than in the worst games; this difference was marginally significant (\( t(11) = 1.91, p = 0.081 \)).

In summary, this first type of APT analysis confirmed that the turns that were coded as effective were indeed more likely to recur in games with higher scores than in games with lower scores. It also showed that the activities that generate more points in the game, *Demonstration* and *Training Workshop*, were used effectively more often in the best games.

**Individual Setting Patterns**

The second APT analysis examined differences in the games played by participants in the individual setting who obtained the two highest, the two middle and
the two lowest average scores across all games. They had played using the think-aloud technique, describing what they were thinking and planning to do. The researcher transcribed and coded each turn played by these six individual players using the APT classifications described in the previous chapter and which are summarized in the following table:

Table 4.12
APT classifications used in the individual setting

<table>
<thead>
<tr>
<th>Classification</th>
<th>Description</th>
<th>Categories</th>
</tr>
</thead>
<tbody>
<tr>
<td>Turn Reason</td>
<td>Potential reason players conducted a specific activity on each turn.</td>
<td>Cognitive (C)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Continuing Strategy (CS)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Exploring (X)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Previous Turn (PT)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Unknown (U)</td>
</tr>
<tr>
<td>Diffusion Strategy Selection</td>
<td>Whether the activity conducted was appropriate according to diffusion of innovations theory (i.e., in order to succeed in the game), and if not, why</td>
<td>Effective (E)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Non-effective - Did Not Know (NE DK)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Non-effective - Did Not Notice (NE DN)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Non-effective -Forgot (NE F)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Non-effective - Mistake (NE M)</td>
</tr>
</tbody>
</table>

The following table includes an excerpt of the transcript of the first game played by individual 16, one of the players with the highest average scores. It can be observed that the first three turns shown are the result of a cognitive process, such as selecting talking to the Science Teacher in turn 5 based on his description and his lunch mate network, thus these turns were coded as Cognitive (C) in the “Turn Reason” classification.
Table 4.12 also shows that in turn 16, the player conducted a Blog Post activity, which was the first time she had conducted this type of activity. She did not have a clear expectation about its outcome and conducted it in an exploratory way, “just to see if teachers actually read it”. A Blog Post influences mainly opinion leaders, raising their awareness and interest about the innovation. However, since at this point in the game opinion leaders were already beyond the Interest phase, the turn was not effective. Since this was the first time this activity was conducted, the player did not know about the impact and appropriateness of this activity, thus the Diffusion Strategy Selection classification was coded as Not Effective - Did not Know (NE-DK).
In order to be coded as “Cognitive” or “Exploratory” participants had to externalize their thoughts, providing an explanation about why they were conducting the activity. Turns in which an activity was conducted without any explanation, the “Turn Reason” classification was coded as “Unknown”. All the games, complete and incomplete, from the six individual players were coded. There was a total of 949 turns coded. The following table includes the number of total turns coded per each of the players:

Table 4.14
Total turns coded from players in the individual setting

<table>
<thead>
<tr>
<th>Player</th>
<th>Total Games Played</th>
<th>Complete Games</th>
<th>Total Turns</th>
</tr>
</thead>
<tbody>
<tr>
<td>In_16</td>
<td>4</td>
<td>3</td>
<td>80</td>
</tr>
<tr>
<td>In_11</td>
<td>9</td>
<td>3</td>
<td>210</td>
</tr>
<tr>
<td>In_17</td>
<td>4</td>
<td>4</td>
<td>160</td>
</tr>
<tr>
<td>In_5</td>
<td>6</td>
<td>3</td>
<td>91</td>
</tr>
<tr>
<td>In_13</td>
<td>6</td>
<td>3</td>
<td>198</td>
</tr>
<tr>
<td>In_22</td>
<td>6</td>
<td>3</td>
<td>210</td>
</tr>
</tbody>
</table>

APT analysis was used to count the joint occurrences per each of the categories from the Turn Reason and Diffusion Strategy Selection classifications. Since high performing players have been found to use more strategic thinking than low performing players (Hong & Liu, 2003), the following hypothesis had been posited:

Hypothesis 6: Game performance will be related to the total number of turns that were played using strategic thinking and cognitive processes.
The following table summarizes the proportions of occurrences found among the six individual players:

Table 4.15
Summary of APT analysis of games in the individual setting

<table>
<thead>
<tr>
<th>Turn Reason</th>
<th>Cognitive &amp; Effective</th>
<th>Previous Turn &amp; Effective</th>
<th>Diffusion Strategy Selection</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Not Effective - Didn't Know</td>
</tr>
<tr>
<td><strong>Top 2 Individuals</strong></td>
<td></td>
<td></td>
<td>0.150</td>
</tr>
<tr>
<td>In_16</td>
<td>0.263</td>
<td>0.338</td>
<td>0.115</td>
</tr>
<tr>
<td>In_11</td>
<td>0.076</td>
<td>0.371</td>
<td>0.100</td>
</tr>
<tr>
<td>Average</td>
<td>0.169</td>
<td>0.354</td>
<td>0.165</td>
</tr>
<tr>
<td><strong>Middle 2 Individuals</strong></td>
<td></td>
<td></td>
<td>0.132</td>
</tr>
<tr>
<td>In_17</td>
<td>0.088</td>
<td>0.288</td>
<td>0.091</td>
</tr>
<tr>
<td>In_5</td>
<td>0.209</td>
<td>0.242</td>
<td>0.133</td>
</tr>
<tr>
<td>Average</td>
<td>0.148</td>
<td>0.265</td>
<td>0.112</td>
</tr>
<tr>
<td><strong>Bottom 2 Individuals</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>In_13</td>
<td>0.056</td>
<td>0.167</td>
<td></td>
</tr>
<tr>
<td>In_22</td>
<td>0.075</td>
<td>0.183</td>
<td></td>
</tr>
<tr>
<td>Average</td>
<td>0.065</td>
<td>0.175</td>
<td></td>
</tr>
</tbody>
</table>

As it can be observed in the table above, in terms of the reason for conducting a specific activity on each turn, lower performing individual players had fewer effective turns that were the result of externalized cognitive processes and of applying what they have learned from previous turns. These findings were aligned with the original hypothesis: players who obtained a higher average score across multiple games, also exhibited greater number of turns in which they applied cognitive processes. The mean proportion of conducting effective turns that were result of an externalized cognitive process was 0.169 for the higher performing individual players and it was 0.065 for the lower performing individual players. In other words, higher performing individual players conducted this type of turn 2.6 (0.169 / 0.065) times more often than the lower performing individuals. Moreover, higher performing individual players conducted twice
as many activities that had been previously identified being theoretically effective than the lower performing individuals.

In terms of the reasons for conducting not effective strategies, middle and lower performing individual players were over three \((0.186 / 0.055 = 3.38)\) times more likely to repeat unsuccessful strategies due to having forgotten specific information about the activities or the staff members selected. The most common forgotten situations were:

1. Attempting to conduct an activity that required conducting a prior one, such as trying to conduct a *Demonstration* or a *Training Workshop* without having talked to the *Principal*, or trying to *Talk to the Principal* without having *Talked to the Secretary*.

2. Conducting an activity at the wrong time, such as attempting to conduct a *Blog Post* or *Presentation* during the busiest months or a *Training Workshop* when most staff members have not reached the *Trial* phase, which is the most appropriate phase for this activity.

3. Targeting staff members with activities that have been previously identified as not being successful, such as attempting to *Talk to* a staff member whose adopter type is *Late Majority* or *Lag gard*.

An additional difference between the highest and lowest performing individual players in terms of using not effective strategies was that the latter were 1.82 \((0.348 / 0.191)\) times more likely to fail to notice information or hints on the feedback provided in the game when conducting some activities. For instance, one of the activities players can conduct is a *Site Visit*, in which they can select up to three staff members to visit a school that has already implemented the innovation. Part of the feedback that is always shown
after conducting a Site Visit activity reads: “Gain 2 points in the Awareness or Interest phases for each of the visitors (not including Principal).”

After players conduct a Site Visit activity a few times, it is expected that they realize that such activity is effective only for staff members who are in the Awareness or Interest phases and that it is not effective for the Principal. However, both participants with the lowest scores continued using this activity by selecting the Principal or staff members who were beyond the Interest phase. In a game, one of these participants used this activity ineffectively in 25% of the turns. Since participants were not asked to read aloud the feedback provided by the game and neither were they interviewed after the game session, it was not clear whether they had read the whole feedback and did not understand it or had just skimmed it and skipped some parts of it.

Collaborative Setting Patterns

In the third APT analysis, I investigated the differences in the games played by participants in the collaborative setting. For this purpose, I transcribed and coded each turn played by those dyads that had obtained the two highest, the two middle and the two lowest average scores across all games. In addition to the players’ dialogue, each transcript included the time in which an information or diffusion activity was conducted, observations about what players were doing within the game, points obtained per turn, the activity conducted and who conducted it, and the number of the week elapsed. The following table contains an excerpt of the transcript of a turn played by participants in team 8. The conversation flows from top to bottom. When both participants talked at the same time, the transcription was entered in the same row.
Table 4.16

Excerpt of transcript of game play in the collaborative setting

<table>
<thead>
<tr>
<th>Week</th>
<th>Time</th>
<th>Player 1</th>
<th>Player 2</th>
<th>Observations</th>
<th>Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>25</td>
<td>15:35</td>
<td>What else can we try?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Who is connected with the Principal? Let me see.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Math Chair and science teacher.</td>
<td>Science teacher…</td>
<td>Both looking at lunch mates diagram</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Let’s try a pilot test with the Science teacher</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Okay</td>
<td></td>
</tr>
<tr>
<td>27</td>
<td>16:10</td>
<td></td>
<td></td>
<td>Science Teacher got 3 points, Principal 2, Math Chair 2.</td>
<td>Player 1 – Pilot Test with Science Teacher</td>
</tr>
</tbody>
</table>

The same APT classifications and categories used for analyzing the differences in the individual setting were also used in the collaborative setting. However, in order to analyze the interaction between participants, three additional classifications were included. The following table summarizes the classifications and their categories.

Table 4.17

List of APT classifications used in the collaborative setting

<table>
<thead>
<tr>
<th>Classification</th>
<th>Description</th>
<th>Category</th>
</tr>
</thead>
<tbody>
<tr>
<td>Turn Reason</td>
<td>Potential reason players conducted a specific activity on each turn.</td>
<td>Cognitive (C)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Continuing Strategy (CS)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Exploring (X)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Previous Turn (PT)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Unknown (U)</td>
</tr>
<tr>
<td>Diffusion Strategy Selection</td>
<td>Whether the activity conducted was appropriate according to diffusion of</td>
<td>Effective (E)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Non-effective - Did Not Know (NE DK)</td>
</tr>
</tbody>
</table>
innovations theory (i.e., in order to succeed in the game), and if not, why

<table>
<thead>
<tr>
<th>Collaboration level</th>
<th>Extent to which teammates collaborated in deciding the activity to conduct in a turn.</th>
<th>Non-effective - Did Not Notice (NE DN)</th>
<th>Non-effective - Forgot (NE F)</th>
<th>Non-effective - Mistake (NE M)</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Decider</th>
<th>Player(s) who made the decision to conduct the activity in the turn</th>
<th>Player 1 (P1D)</th>
<th>Player 2 (P2D)</th>
<th>Both (BD)</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Suggestions</th>
<th>Player(s) who made suggestions during the turn</th>
<th>Player 1 (P1S)</th>
<th>Player 2 (P2S)</th>
<th>Both (BS)</th>
<th>None (NS) (no suggestions)</th>
<th>NULL (no one talked)</th>
</tr>
</thead>
</table>

An excerpt of the APT data for the first game from one of the teams is shown in the table below. For sake of space, some columns were not included such as the staff members selected for each activity and the timestamp when the turn was conducted.

Table 4.18
Sample of APT temporal map from the first game of Team 8

<table>
<thead>
<tr>
<th>Team</th>
<th>Game</th>
<th>Turn</th>
<th>Week</th>
<th>Player</th>
<th>Action</th>
<th>Collab. Level</th>
<th>Turn Reason</th>
<th>Diffusion Strategy Selection</th>
<th>Suggestions</th>
<th>Turn Decider</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>Player 2</td>
<td>Personal Info</td>
<td>N</td>
<td>U</td>
<td>E</td>
<td>Player 1</td>
<td>Both</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>2</td>
<td>Player 1</td>
<td>Talk to</td>
<td>U</td>
<td>U</td>
<td>NE-DK</td>
<td>None</td>
<td>Player 1</td>
<td>Player 1</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>3</td>
<td>Player 2</td>
<td>Talk to</td>
<td>N</td>
<td>C</td>
<td>NE-DK</td>
<td>Both</td>
<td>Player 2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>4</td>
<td>Player 1</td>
<td>Personal Info</td>
<td>PN</td>
<td>C</td>
<td>E</td>
<td>Both</td>
<td>Player 2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>5</td>
<td>Player 2</td>
<td>Personal info</td>
<td>PN</td>
<td>CS</td>
<td>E</td>
<td>None</td>
<td>Player 2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>6</td>
<td>Player 1</td>
<td>Personal info</td>
<td>PN</td>
<td>CS</td>
<td>E</td>
<td>None</td>
<td>Player 1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>9</td>
<td>Player 2</td>
<td>Pilot Test</td>
<td>N</td>
<td>C</td>
<td>E</td>
<td>Both</td>
<td>Both</td>
<td></td>
</tr>
<tr>
<td></td>
<td>8</td>
<td>11</td>
<td>Player 1</td>
<td>Pilot Test</td>
<td>PN</td>
<td>CS</td>
<td>E</td>
<td>Player 1</td>
<td>Player 1</td>
<td></td>
</tr>
</tbody>
</table>
All turns, including those from the incomplete games, were coded. There was a total of 663 turns, 30% fewer turns than those in the games from the six individual participants analyzed in the previous section. There was no correlation between the number of turns played and the average game performance. The following table includes the total number of turns that were coded for each of the dyads.

Table 4.19
Number of turns coded per team

<table>
<thead>
<tr>
<th>Teams</th>
<th>Number of turns coded</th>
</tr>
</thead>
<tbody>
<tr>
<td>Top</td>
<td></td>
</tr>
<tr>
<td>Team 8</td>
<td>94</td>
</tr>
<tr>
<td>Team 4</td>
<td>130</td>
</tr>
<tr>
<td>Middle</td>
<td></td>
</tr>
<tr>
<td>Team 6</td>
<td>102</td>
</tr>
<tr>
<td>Team 2</td>
<td>98</td>
</tr>
<tr>
<td>Bottom</td>
<td></td>
</tr>
<tr>
<td>Team 10</td>
<td>125</td>
</tr>
<tr>
<td>Team 11</td>
<td>114</td>
</tr>
</tbody>
</table>

The following table summarizes the proportions of the Turn Reason and Diffusion Strategy Selection classifications.

Table 4.20
Summary of Turn Reason and Diffusion Strategy Selection classifications analyses in the collaborative setting

<table>
<thead>
<tr>
<th>Turn Reason</th>
<th>Diffusion Strategy Selection</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cognitive &amp; Effective</td>
<td>Not Effective -Didn't Know</td>
</tr>
<tr>
<td>Previous Turn &amp; Effective</td>
<td>Not Effective -Didn't Notice</td>
</tr>
<tr>
<td>Not Effective -Forgot</td>
<td></td>
</tr>
<tr>
<td>Top 2 Teams</td>
<td></td>
</tr>
<tr>
<td>Team 8</td>
<td>0.234</td>
</tr>
<tr>
<td>Team 4</td>
<td>0.154</td>
</tr>
<tr>
<td>Average</td>
<td>0.194</td>
</tr>
<tr>
<td>0.160</td>
<td>0.064</td>
</tr>
<tr>
<td>0.146</td>
<td>0.100</td>
</tr>
<tr>
<td>Average</td>
<td></td>
</tr>
<tr>
<td>Not Effective -Forgot</td>
<td></td>
</tr>
<tr>
<td>Top 2 Teams</td>
<td></td>
</tr>
<tr>
<td>Team 2</td>
<td>0.255</td>
</tr>
<tr>
<td>Average</td>
<td>0.173</td>
</tr>
<tr>
<td>0.163</td>
<td>0.082</td>
</tr>
<tr>
<td>0.051</td>
<td></td>
</tr>
<tr>
<td>Middle 2 Teams</td>
<td></td>
</tr>
<tr>
<td>Team 2</td>
<td>0.255</td>
</tr>
<tr>
<td>Average</td>
<td>0.173</td>
</tr>
<tr>
<td>0.163</td>
<td>0.082</td>
</tr>
<tr>
<td>0.087</td>
<td></td>
</tr>
</tbody>
</table>
Similarly to the findings in the individual setting, one the main differences between the higher and lower performing dyads regarding the reasons for conducting an activity were that the higher performing dyads conducted more activities as a result of an externalized cognitive process and of applying what they have learned from previous turns. On average, higher performing dyads conducted 1.85 times (0.194 / 0.105) more activities that were result of a cognitive process and 1.76 times (0.294 / 0.167) more activities that had been previously identified as being effective, compared with low performers. Moreover, in terms of the reasons for conducting ineffective strategies, the lowest performing dyads conducted 2.5 times (0.209 / 0.082) more unsuccessful activities for failing to observe information or hints on the feedback provided. These differences were smaller between the highest and middle performing teams, but their differences on their average scores across all games was small as well.

Regarding the differences in participants’ interaction between the higher and lower performing dyads, the following hypotheses had been put forward:

*Hypothesis 7: In the collaborative setting, game performance will be related to the dyads’ degree of participation, exchanges of ideas, and sharing of information.*

To test this hypothesis, APT analysis was conducted to examine patterns in (a) the level of collaboration between participants, (b) participation contribution with
suggestions or ideas, (c) involvement in the decision making process, and (d) frequency of communication. The following sections describe each of them.

**Collaboration level patterns.** The Collaboration level APT classification measured the extent to which team participants collaborated in deciding the activity to conduct in a turn. This classification included four categories:

Negotiation (N) – The activity was conducted as a result of dialog or discussion between players that included sharing information, elaborating a suggestion, expressing different opinions, identifying inconsistencies, and participating in the decision process.

Passive Negotiation (PN) - A player suggests conducting an activity and the other player consents without elaborating on the suggestion.

Unilateral Decision (U) – In his/her turn, a player conducts an activity (which was not previously discussed) without the other player’s opinion.

Command (C) - A player orders his/her teammate to conduct an activity.

The following table summarizes the percentages of collaboration level for the six analyzed teams.

<table>
<thead>
<tr>
<th>Collaboration Level Pattern</th>
<th>Top 2 Teams</th>
<th>Middle 2 Teams</th>
<th>Bottom 2 Teams</th>
</tr>
</thead>
<tbody>
<tr>
<td>Team 8</td>
<td>0.556</td>
<td>0.427</td>
<td>0.245</td>
</tr>
<tr>
<td>Team 4</td>
<td>0.385</td>
<td>0.490</td>
<td>0.533</td>
</tr>
<tr>
<td>Average</td>
<td><strong>0.470</strong></td>
<td><strong>0.492</strong></td>
<td><strong>0.432</strong></td>
</tr>
<tr>
<td>Team 2</td>
<td>0.427</td>
<td>0.490</td>
<td>0.000</td>
</tr>
<tr>
<td>Team 6</td>
<td>0.437</td>
<td>0.493</td>
<td>0.027</td>
</tr>
<tr>
<td>Average</td>
<td><strong>0.432</strong></td>
<td><strong>0.492</strong></td>
<td><strong>0.432</strong></td>
</tr>
</tbody>
</table>

Table 4.21
Summary of the collaboration level between dyads
By counting the number of occurrences in which game turns had been coded as “Negotiation”, it was observed that, on average, the higher performing teams had conducted almost twice as many negotiated turns \((0.470 / 0.24 = 1.96)\) than the lower performing teams. The proportions of negotiation in interactions decreased across most game plays for the six teams. This difference was more pronounced in lower performance teams, in which it decreased by more than half. Two of the reasons observed by the researcher regarding why the negotiated turns declined across multiple games were (1) some dyads kept using previously identified effective activities that did not need further discussion and (2) in some dyads, one of the player’s participation dwindled while conceding more decision control to his/her teammate.

On average, compared to the higher performing teams, lower performing teams had 1.42 more turns \((0.52 / 0.366)\) using passive negotiation and had more than twice as many turns \((0.22 / 0.095 = 2.31)\) that used unilateral decisions. On the other hand, higher performing teams exhibited over four times more turns \((0.062 / 0.014 = 4.43)\) in which one of the players commanded the other conducting specific activities than lower performing teams.

**Suggestion contribution patterns.** This analysis examined the differences of participants’ contribution of suggestions or ideas proposed within a turn. The categories used in this classification were:

Player 1 (P1S). Only one of the participants, coded as P1, made one or more suggestions in the turn.
Player 2 (P2S). Only the other participant made one or more suggestions.

Both (BS). Both participants made suggestions.

None (NS). Participants talked within the turn but either made a suggestion.

NULL. Participants played the turn without talking.

Table 4.22
Summary of suggestion contribution pattern

<table>
<thead>
<tr>
<th>Suggestion Contribution Pattern</th>
<th>Both Players made Suggestions</th>
<th>Neither Player made Suggestions</th>
<th>At least one Player Suggested</th>
<th>Effective Turns with Suggestions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Top 2 Teams</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Team 8</td>
<td>0.479</td>
<td>0.128</td>
<td>0.851</td>
<td>0.688</td>
</tr>
<tr>
<td>Team 4</td>
<td>0.277</td>
<td>0.262</td>
<td>0.677</td>
<td>0.646</td>
</tr>
<tr>
<td>Average</td>
<td>0.378</td>
<td>0.195</td>
<td>0.764</td>
<td>0.667</td>
</tr>
<tr>
<td>Middle 2 Teams</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Team 2</td>
<td>0.424</td>
<td>0.212</td>
<td>0.786</td>
<td>0.541</td>
</tr>
<tr>
<td>Team 6</td>
<td>0.370</td>
<td>0.174</td>
<td>0.796</td>
<td>0.490</td>
</tr>
<tr>
<td>Average</td>
<td>0.397</td>
<td>0.193</td>
<td>0.791</td>
<td>0.516</td>
</tr>
<tr>
<td>Bottom 2 Teams</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Team 10</td>
<td>0.226</td>
<td>0.240</td>
<td>0.728</td>
<td>0.506</td>
</tr>
<tr>
<td>Team 11</td>
<td>0.187</td>
<td>0.318</td>
<td>0.535</td>
<td>0.541</td>
</tr>
<tr>
<td>Average</td>
<td>0.206</td>
<td>0.279</td>
<td>0.632</td>
<td>0.524</td>
</tr>
</tbody>
</table>

As it can be observed in the table above, on average, compared to the lower performing teams, higher performing teams conducted 1.84 (0.378 / 0.206) more turns in which both players made suggestions, 1.21 more turns (0.764 / 0.632) in which at least one of the participants made suggestions, and 1.27 more turns (0.667 / 0.524) that were both effective and in which at least one participant made a suggestion. In contrast, lower performing teams conducted 1.43 more turns (0.279 / 0.195) in which neither player made any suggestion than the higher performing teams.
Decision involvement patterns. The differences of the amount of team members involvement in the decision making process of conducting a DSG activity (i.e. Demonstration, Blog Post) were also investigated.

For each turn, the participant who had made the decision of selecting the activity and its corresponding staff members was coded as Player 1 or Player 2. If both participants had contributed in the decision process, it was coded as Both. In order to calculate the proportions in which a player was involved in the decision process, the joint occurrences of having Player 1, Player 2, and Both were applied to the formula:

\[
\frac{\text{Player 1} + \text{Both}}{\text{((Player 1} + \text{Both}) + (\text{Player 2} + \text{Both}))}
\]

For example, the decision of conducting 11 out of all of the turns of Team 8 was done exclusively by one of the participants (team8_a) whereas 65 of them were decided exclusively by the other participant (team8_b). Both of them decided together 18 turns. Thus, the percentage of the participant team8_a involvement in the decision process was 

\[
\frac{11 + 18}{(11 + 18) + (65 + 18)} = 0.259
\]

The following table includes the summary of the percentages of turns in which each player contributed in the decision making process.

Table 4.23
Proportions of participants’ decision-making process involvement

<table>
<thead>
<tr>
<th>Decision Making Involvement</th>
<th>Student Id</th>
<th>Decider</th>
<th>Student Id</th>
<th>Decider</th>
</tr>
</thead>
<tbody>
<tr>
<td>Top Teams</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Team8_a</td>
<td>0.259</td>
<td>Team8_b</td>
<td>0.741</td>
<td></td>
</tr>
<tr>
<td>Team4_a</td>
<td>0.729</td>
<td>Team4_b</td>
<td>0.271</td>
<td></td>
</tr>
<tr>
<td>Middle Teams</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Team2_a</td>
<td>0.517</td>
<td>Team2_b</td>
<td>0.483</td>
<td></td>
</tr>
<tr>
<td>Team6_a</td>
<td>0.570</td>
<td>Team6_b</td>
<td>0.430</td>
<td></td>
</tr>
<tr>
<td>Bottom Teams</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Team10_a</td>
<td>0.336</td>
<td>Team10_b</td>
<td>0.664</td>
<td></td>
</tr>
</tbody>
</table>

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An interesting similarity found between the higher-performing and lower-performing teams was that on average one of the players participated more actively than his/her teammate in the decision-making process per turn. On each of these four teams, one of the players was involved in deciding the next move over 70% of all turns on average while their teammates were just involved in decision process of the remaining 30% of the turns. This disparity was significantly lower in the middle-performing teams, in which the difference of decision involvement between participants was less than 15%.

As it will be explained in the next section, the players who participated more actively in the decision-process were associated with higher gains in learning as measure by the difference between the pre- and post- tests.

To exemplify the differences between the higher and lower performing dyads with regards to the levels of collaboration, suggestion contribution, and decision-making process involvement per player, an abstract of the dialogue between participants in one of the lower-performing teams is included below. In this game, both participants took a top-down approach to solve the DSG, conducting activities that targeted the Principal 25% of all turns. Before this dialogue, player “team10_1” had just tried unsuccessfully to talk to the Principal.

**Player Team10_2:** He's the Principal, so we really need to have him to adopt.
**Player Team10_1:** Yeah, if we hold the demonstration with him, people will just have to follow…
**Player Team10_2:** I guess we can talk to the Social Studies Teacher and then we can try the Principal again later on.
**Player Team10_1:** Okay.

(Player Team_10_2 talks to Social Studies Teacher, no points are gained)
Player Team10_2: Ah, he’s a dick too!
Player Team10_1: All right.
Player Team10_2: Talk to the Principal again.
Player Team10_1: Sure.

(Player Team10_1 talks to the Principal, no points are gained)

Player Team10_1: Nothing.
Player Team10_2: Shall I talk to him again?
Player Team10_1: Yeah.

(Player Team10_1 talks to the Principal, no points are gained)

As it can be observed, the dialogue above includes three turns, and in all of them both players kept insisting in targeting the Principal even though it had not worked for them before. Furthermore, the decisions of selecting the activities in all three turns were made by one of the participants while the other one mostly agreed passively. Conversely, the amount of opposite opinions and information exchange in the higher-performing teams was more evident as it can be noticed in the following conversation, which takes place after the players had tried talking to the Principal twice before.

Player Team4_1: Okay, so now let’s try to talk to the Principal.
Player Team4_2: Let’s try something else rather than just talking to him.
Player Team4_1: Okay, so maybe… a Workshop?
Player Team4_2: Mmmh… what else can we try? Who is the Principal connected with?
Player Team4_1: Math Chair and Science Teacher (Looking at lunch mates).
Player Team4_2: Let’s try…
Player Team4_1: The Art Teacher is connected to the Language Arts Chairwoman (Still looking at lunch mates diagram).
Player Team4_2: Yes.
Player Team4_1: So maybe we should try a Training Workshop?
Player Team4_2: Again?
Player Team4_1: But it takes three weeks… maybe we could try something else.
Player Team4_2: We could do a Pilot Test with someone.
Player Team4_1: Yeah, let’s try the Pilot… yeah, we haven’t even used that.

(Player Team4_1 conducts a Pilot Test with the Math teacher)
Frequency of communication patterns. This analysis was aimed at examining the differences in the total amount of words used among the dyads. The degree of participation within a group has been reported as being positively correlated to the performance of the tasks (Williams & Sternberg, 1988), for this reason, as part of this last hypothesis, it was expected to find more frequency of communication in higher performing teams. The following table summarizes the percentages of words spoken per player during each game and also the total number of words spoken by each of the players.

Table 4.24
Analysis of frequency of communication in dyads

<table>
<thead>
<tr>
<th>Team 8</th>
<th>Words spoken</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Time</td>
</tr>
<tr>
<td>Game 1</td>
<td>34</td>
</tr>
<tr>
<td>Game 2</td>
<td>21</td>
</tr>
<tr>
<td>Game 3</td>
<td>16</td>
</tr>
<tr>
<td>Game 4</td>
<td>11</td>
</tr>
<tr>
<td>AVG</td>
<td>20.5</td>
</tr>
<tr>
<td>St. Dev.</td>
<td>9.88</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Team 4</th>
<th>Words spoken</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Time</td>
</tr>
<tr>
<td>Game 1</td>
<td>23</td>
</tr>
<tr>
<td>Game 2</td>
<td>14</td>
</tr>
<tr>
<td>Game 3</td>
<td>10</td>
</tr>
<tr>
<td>AVG</td>
<td>15.7</td>
</tr>
<tr>
<td>St. Dev.</td>
<td>6.66</td>
</tr>
</tbody>
</table>

Middle 2 Teams

<table>
<thead>
<tr>
<th>Team 2</th>
<th>Words spoken</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Time</td>
</tr>
<tr>
<td>Game 1</td>
<td>38</td>
</tr>
<tr>
<td>Game 2</td>
<td>14</td>
</tr>
<tr>
<td>Game 3</td>
<td>13</td>
</tr>
</tbody>
</table>
Contrary to the original expectations, the frequency of communication in the higher-performing teams was not lower than in the lower-performing teams. In the latter, the total amounts of words spoken by both players were very close, both teams speaking over 1,300 words. However, one of the teams in the higher- and in middle-performing teams spoke fewer than 1,000 words.
By analyzing the data on the previous table, it can be observed that the difference of total words spoken per player was twice as much in the lower-performing teams than in the top and middle-performing teams. In other words, on average, the lower-performing teams had a team member who spoke 40% or more than his/her teammate while this difference was 20% or less in the top and middle-performing teams. It was also observed that the participants who dominated the conversation in the lower-performing teams were also 40% or more involved in making the decisions about what activity to conduct on each turn.

In five out of the six teams investigated there was one player who took a more active role in each game either by talking 20% or more than his/her teammate, or by being involved 40% or more in the decision making process to conduct the activities on each turn. There was only one team, Team 2, in which both participants were almost equally active. The following table summarizes participants’ level of involvement in the game and their gains in learning. The values corresponding to the more active players per team are bolded.

<table>
<thead>
<tr>
<th>Teams</th>
<th>Student Id</th>
<th>Decision Involvement</th>
<th>Words Spoken</th>
<th>Pre-Test</th>
<th>Post-Test</th>
<th>Post-Pre</th>
</tr>
</thead>
<tbody>
<tr>
<td>Team 2</td>
<td>team2_a</td>
<td>52%</td>
<td>53%</td>
<td>8.33</td>
<td>10.33</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>team2_b</td>
<td>48%</td>
<td>47%</td>
<td>4.33</td>
<td>11.66</td>
<td>7.33</td>
</tr>
<tr>
<td>Team 4</td>
<td>team4_a</td>
<td>73%</td>
<td>60%</td>
<td>4.66</td>
<td>12.66</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>team4_b</td>
<td>27%</td>
<td>40%</td>
<td>4.33</td>
<td>8.66</td>
<td>4.33</td>
</tr>
<tr>
<td>Team 6</td>
<td>team6_a</td>
<td>57%</td>
<td>41%</td>
<td>3.33</td>
<td>12.66</td>
<td>9.33</td>
</tr>
<tr>
<td></td>
<td>team6_b</td>
<td>43%</td>
<td>59%</td>
<td>5.66</td>
<td>7.66</td>
<td>2</td>
</tr>
<tr>
<td>Team 8</td>
<td>team8_a</td>
<td>26%</td>
<td>46%</td>
<td>5.33</td>
<td>6</td>
<td>0.67</td>
</tr>
</tbody>
</table>
As it can be observed in the table above, in teams in which one player was 20% or more active than the other, the dominating player had higher post-test scores and gains in learning than his/her teammate, with an average gains in learning of 7.6 ((8 + 9.33 + 8.67 + 5.34 + 6.67) / 5) whereas it was 2.2 ((4.33 + 2 + 0.67 + -1 + 5) / 5) for their teammates.

**Summary of APT findings**

The following findings were observed regarding the differences of patterns between the games with the highest and the lowest scores:

In both settings, the games with the highest scores exhibited having used the following four diffusion of effective innovation strategies significantly more often than the games with the lowest scores: (1) targeting opinion leaders, and (2) using *Blog Post* to raise awareness (3) conducting *Demonstration* to raise interest, and (4) conducting *Training Workshop* to raise trial and appraisal.

In the individual setting, participants with the highest average score across all their games conducted effective turns that were result of an externalized cognitive process 2.6 times more often than participants with the lowest average score. Moreover, higher performing individual players conducted twice as many activities that had been previously identified as being effective. Lower performing individual players were over
three times more likely to repeat non-effective activities due to having forgotten information or feedback about the previous activities conducted.

In the collaborative setting, the two dyads with the highest average score conducted 1.85 times more activities that were result of a cognitive process and 1.76 more activities that had been previously identified as being effective than the two dyads with the lowest average score. Moreover, the latter were 2.5 times more likely to repeat non-effective activities for failing to observe information or hints on the feedback provided. Regarding the differences in the collaboration process, higher performing dyads conducted more turns as a result of dialog or discussion and both participants were actively involved in contributing with suggestions or ideas.

**Overall chapter summary**

This chapter has presented the findings of the three research questions that guided this study. The first research question investigated the differences in game performance, learning, and attitudes among learners playing the DSG in an individual setting versus playing it in a collaborative setting. A series of independent sample *t*-tests was conducted to compare game scores, gains in learning, and attitudinal scores between both settings. On average, participants in the collaborative obtained a statistically significantly higher game score; however the difference in gains in learning was not statistically significant. In both settings, participants had a neutral attitude towards having played the game in the setting assigned.

The second research question examined the relationship between personality traits and performance and attitudes. A series of Spearman correlations was used for this purpose. In the individual setting, conscientiousness was correlated to game performance
and extraversion was negatively correlated to gains in learning. In the collaborative setting both agreeableness and extraversion were negatively correlated to game performance whereas conscientiousness and openness to experience were related to gains in learning. In addition, there was a significant correlation between participants’ preference towards having played the game collaboratively and their level of extraversion.

The third research question examined and compared the differences of patterns of strategies used between the games with the highest and the lowest scores. APT analysis was conducted to examine these differences. In both settings, higher performing players conducted on average more turns as a result of externalized cognitive processes and repeating activities that had been previously identified as being effective. In the collaborative setting, higher performing dyads conducted more turns that involved active negotiation which included sharing information, making suggestions, expressing different opinions, identifying inconsistencies, and participating in the decision process.
CHAPTER V: DISCUSSION AND CONCLUSIONS

Online education has become more pervasive in the United States in recent years. Allen and Seaman (2012) reported that, as of 2012, over 60% of higher education institutions provided complete online programs and that the online enrollment as a percent of total enrollment was 32% (higher than any previous year). For its intrinsic dependence in electronic communication media, the interaction that takes place in the online environment differs from face-to-face interaction (Culnan & Markus, 1987; Daft & Lengel, 1984; Kock, 2005; Sproull & Kiesler, 1986). For this reason it is important to examine whether instructional strategies that have proven to be effective in face-to-face courses, such as collaborative learning, also remain effective when delivered online.

This study investigated the impact of implementing a collaborative instructional strategy when playing an online educational simulation game, comparing team versus individual performance. The relationship among players’ performance, their personality traits, and their reactions towards having used the game as an educational vehicle were also examined.

The educational game used in this study was a modified version of the Diffusion Simulation Game (DSG), which teaches concepts and strategies related to the diffusion of innovations theory (DoI), as described by Rogers (2003). In the DSG, the player takes the role of a teacher who, acting as a “change agent”, has the goal to persuade the rest of the staff in a junior high school to adopt peer-tutoring as an instructional innovation (Molenda & Rice, 1979). To achieve that goal, players can conduct several activities (e.g., Presentation, Pilot Test, or Demonstration) with specific staff members. The level of effectiveness of these activities varies in function of (a) the extent to which the staff
member selected is reluctant to change (in DoI theory this is known as *adopter type* and it ranges from being an *innovator* to being a *laggard*) (b) the staff member’s existing level of familiarity with the instructional innovation (in DoI theory this is known as the *adoption phase*), (c) the number of staff members who have already adopted (also known as *critical mass*), and (d) whether the *Principal* has already adopted (see Appendix A for the description of activities and staff members included in the game).

The study involved 44 participants who were randomly assigned to either an individual or a collaborative setting. In both settings, participants played the game as many times as they wanted during an 80-minute period. The game sessions took place within the virtual world called Second Life. Cooperative learning strategies such as positive interdependence, group monitoring, and individual accountability were implemented to foster collaboration between participants playing in pairs.

Gains in learning about the DoI theory were measured by a 15-item instrument administered first as a pre-test at least one day prior to the game session and then later as a post-test. An incentive was offered to encourage all participants. They were provided the possibility of participating in two $50 prize drawings based on their combined performance in both the game and the post-test. The remainder of this chapter discusses the findings for each of the research questions that guided this study, its implications for practice, limitations, as well as suggestions for further research.

The first research question examined the differences in game performance, learning, and attitudes among participants playing the DSG individually versus playing it collaboratively in dyads. In terms of game performance, even though participants playing individually completed more games on average, they were outperformed by participants
playing collaboratively, $t(31) = 1.711, p = 0.0485$ (1-tailed). This finding is aligned with several peer-interaction theories (i.e. cognitive elaboration, social constructivist theory, cooperative learning) and with similar studies comparing individual versus collaborative performance in a problem-solving task lasting less than four hours (Barron, 2000; Dansereau, 1988; Mullins, Rummel, & Spada, 2011). The cognitive elaboration perspective postulates that the process of explaining material to a peer or correcting his/her omissions and errors facilitates remembering new information and relating it to their existing knowledge (Dansereau, 1988). Social constructivism posits that peer interaction facilitates complex reasoning and problem-solving skills (Vygotsky, 1978).

Based on the cooperative learning theory, when the interaction among team members has a certain level of structure (e.g., including positive interdependence, individual accountability, etc.), it can enhance problem-solving performance and learning (Johnson & Johnson, 1991; Johnson et al., 1998a; Slavin, 1995; Springer, 1999).

The question arose concerning whether gender may have confounded the relationship between learning setting and game performance. Gender can serve as a proxy variable for factors that may affect learning. For example, males tend to achieve more in mathematics and science subjects (need reference here). It is also known that males tend to play more digital games than do females (ref. needed). When participants were randomly assigned to the setting (individual or collaborative), gender was not considered. In the random assignment process, more females were assigned to the individual setting and more males to the collaborative setting. The proportions of gender departed from the expected proportions when checked by a chi-square test at $p = 0.065$. Therefore, an analysis of covariance was conducted which used gender and prior game
experience as covariates in order to statistically control for their potential effect on
average game performance in the two settings. This did not change the effect of setting
on game performance, which still remained significant in favor of the collaborative
setting, and, in fact, decreased the likelihood of a Type I error.

While playing the DSG collaboratively, participants were able to generate and
share more ideas, to challenge and correct each other thus preventing a greater number of
mistakes, and to identify effective strategies more often than participants playing
individually. For example, in their first game, several players from both settings started
by implementing a top-down approach, which consists of directly targeting the Principal
or the Chairpersons. Even though such an approach is not an effective way to win the
DSG, several individual players continued using it during the entire game session,
whereas those in the collaborative setting warned each other to stop using this strategy
and to attempt another approach.

Regarding gains in learning about the DoI theory, the difference between settings
was not statistically significant: \( t(42) = 1.707, p = 0.364 \). This finding was contrary to the
researcher’s original hypothesis and the literature in cooperative learning, but it was
similar to the outcomes from other studies in which the interaction among team members
took less than 80 minutes. These studies also reported that, in some situations, group
performance failed to be associated with individual learning (Klein & Schnackenberg,
2000; Laughlin & Barth, 1981; Sears, 2013).

To promote positive interdependence and individual accountability, as suggested
by the cooperative learning theory (Johnson & Johnson, 1991; Johnson, Johnson, &
Smith, 1998a; Slavin, 1995), the participants playing the DSG collaboratively were
informed that their eligibility to enter the $50 raffles depended on their combined performance in both the game and the post-test. Teammates needed to answer correctly at least ten out of the fifteen items to enter one of the raffles, and their combined post-test and game scores should have been as high as possible to enter the second raffle. It was thus expected that the participants in the dyads would help each other in learning from the game.

One plausible reason dyads were not able to obtain more significant gains in learning was the short amount of time allotted for their interaction. In a study conducted by Klein and Schnackenberg (2000) in which participants who worked individually obtained significantly higher gains in learning than those who worked in dyads (see Chapter 2), the authors stated that “extending the overall time for instruction may lead to results in favor of cooperative learning not found in the study” (p. 339). Likewise, in the present study, participants in the collaborative setting might have needed more time to ensure that both of them were learning from the game.

Prior to playing the DSG, none of the participants claimed familiarity with concepts and strategies related to the DoI theory, nor did they receive any additional instructional materials about it. Presumably, concepts and strategies they learned were acquired through their interaction with the DSG per se, or the game may have stimulated recall of prior learning or experience, which was then applied during gameplay. Evidence for the latter is that pre-test scores for at least some of the participants were higher than what could be attributed to guessing alone.

In some cases, participants had to overcome cognitive discrepancies during the game session. In a related study that involved 20 participants playing a slightly different
version of the DSG, Enfield (2012) observed that some players held strong beliefs about what they considered to be an effective strategy for diffusing an innovation (e.g., targeting authoritative figures) and were reluctant to try alternative strategies. Thus, an 80-minute period might not have been enough for them to adjust their current beliefs, in addition to identifying, learning, and sharing with his/her teammates effective DoI theory strategies being taught through feedback from playing the game.

A second plausible reason is that dyads played with a “win-approach” instead of a “learn-approach.” During the time dyads interacted playing, most participants were more focused on attempting to win rather than in assuring that his/her teammates were learning from the game. A similar finding was reported by Collazos et al. (2007) who used a digital game to investigate ways to promote computer-based collaboration (see Chapter 2). In their study, they observed that even though the overall quality of the teams’ game performance was acceptable, the teammates did not ensure that all four members of the groups had learned the expected materials; moreover, the authors hypothesized that teammates might have “felt pressured to play instead of stopping to think carefully what to do.” (p. 1030).

Yet, another possible reason why dyads did not obtain higher gains in learning was the disparity of the active involvement between participants in some dyads. In five out of the six dyads analyzed, one of the participants took a more active role across all games on average, either by being involved 40% or more in the decision making process to conduct the activities on each turn or by talking 20% or more than his/her teammate. In these teams, the active participants obtained on average significant higher gains in
learning than their teammates. The participants who had a less active involvement might have not fully understood the reasons why certain activities were effective.

Finally, the imbalance of gender in the two settings could have confounded the relationship between setting and learning gains. When an ANCOVA was conducted, statistically controlling for gender and prior game experience, the main effect of setting on learning gains was still not significant at \( p < 0.05 \).

Gains in learning were statistically significant within each setting. The score difference between pre- and post- tests in the individual setting was \( 3.29 (t(21) = 5.342, p < 0.0001) \) whereas it was \( 4.14 \) in the collaborative setting \( (t(21) = 5.867, p < 0.00001) \). In spite of this significant improvement, the average percentage of questions answered correctly in the post-test was only \( 65\% \) in both settings.

Possible reasons for this low average post-test score were that participants were not exposed to any instructional overlay regarding the DoI theory prior to playing the DSG (cf. Reigeluth & Schwartz, 1989) or to a debriefing session after their gameplay. The test was specifically designed to assess some transfer of learning to a different context in an attempt to rule-out recall of the DSG experience per se. For example, the titles and adopter types of the staff members in the scenario provided by the test were different, so if \( F \) were an opinion leader in the DSG, he was not an opinion leader in the scenario provided by the test. For participants in this study to understand and transfer these concepts, they would have needed to be thinking at a higher level of abstraction than that provided by direct DSG experience and feedback in order to form logical types to classify those experiences (cf. Bateson, 1979). In other words, participants would need to be acting like scientists who make repeated observations of phenomena, who begin to
discriminate patterns, who classify and label the patterns, and who formulate theories about those patterns. The time allotted to play the game may not have been enough for participants to make the necessary observations and to identify all of the patterns.

It is further possible that some participants were able to figure out how to win the DSG at a very concrete level without the higher-level abstraction included in the test (i.e., they were literal thinkers, not scientifically minded). Thus, they could have obtained a high game performance score, yet not shown evidence of considerable transfer of learning on the post-test.

The first research question also examined the differences in participants’ attitudes towards having used the DSG as a learning experience and also towards having played in the setting assigned. On average, 84 percent of all participants agreed or strongly agreed to having enjoyed playing the DSG and 80 percent considered it an effective way to learn. As previously mentioned, the participants’ gains in learning about the DoI theory improved statistically significantly per setting. This finding is aligned with the game-based learning literature that states that games have the power to engage, motivate, and facilitate learning through doing (Kirriemuir & McFarlane, 2004) as well as providing a meaningful environment in which to develop problem-solving skills (Kiili, 2005).

The second research question explored how personality traits correspond with performance, learning, and attitude in students playing the DSG individually and collaboratively. Participants took John’s et al. (2008) Big Five Inventory (BFI) survey that measures five personality traits: agreeableness (i.e., trust, politeness, tolerance) extraversion (i.e., sociability, gregariousness, talkativeness), conscientiousness (i.e., responsibility, reliability, perseverance), neuroticism (i.e., emotional stability, anxiety,
depression, insecurity), and openness to experience (i.e., curiosity, creativity and broad-mindedness).

In partial agreement with personality psychology literature, conscientiousness was found to be marginally significant to game performance in the individual setting ($r = .390, p = .073, n = 22$). This finding indicated that participants that considered themselves as being responsible, persistent, thorough, and reliable obtained higher game scores. Other studies have also reported a positive correlation between conscientiousness and task performance (Bell, 2007; cf. Duckworth et al., 2007; Kichuk & Wiesner, 1997).

Participants playing collaboratively were paired off based on a homogeneous level of agreeableness. Based on other studies related to team performance (Bell, 2007; Kichuk & Wiesner, 1997; Peeters et al., 2006), the researcher had hypothesized that dyads with higher level of agreeableness would perform better in the game. However, contrary to these expectations, the levels of extraversion and agreeableness were negatively correlated to their game performance ($r = -0.459, p = 0.032, n = 22$ and $r = -0.411, p = 0.058, n = 22$ respectively). This indicated that dyads in which both students perceived themselves as highly tolerable, polite, sociable, and talkative, obtained the lowest game scores.

The relationship between personality traits and task performance varies depending on the nature of the task (Driskell et al., 1987), thus not all of the team tasks are conducive to having the same combination of traits to increase performance. For instance, since extraversion is related to talkativeness, extraverts tend to be dominant (Kichuk & Wiesner, 1997) thus this could potentially increase the possibility of conflict with multiple dominant individuals in the same team (Peeters et al., 2006).
When playing the DSG, dyads with a lower level of agreeableness exhibited more negotiation in each game turn whereas those with a higher level accepted passively more suggestions put forward by their teammates. In general, dyads with a lower level of agreeableness had more cognitive disagreement, corrected each other’s mistakes more often, and offered more suggestions.

Regarding the relationship between personality traits and gains in learning, extraversion was found to be negatively correlated in those playing individually ($r = -0.478, p = 0.025, n = 22$). This finding indicated that, regardless of their game performance, individual participants who perceived themselves as more introverted and reserved obtained higher gains in learning. An analogous correlation was not found in the collaborative setting. In other words, extraverts playing in dyads did not exhibit greater gains in learning. In this setting, the personality traits that were marginally correlated to learning were conscientiousness ($r = 0.37, p = 0.09, n = 22$), and openness to experience ($r = 0.39, p = 0.073, n = 22$).

The third and last research question investigated the differences in patterns between the games with the highest and lowest scores as well as examined patterns in the game play strategies used by students within each setting. This question was addressed using Analysis of Patterns in Time (APT), which is a method of recording and quantifying temporal relations about observable phenomena (Frick, 1990). By analyzing all of the games played by those participants with the two highest, two middle, and two lowest average scores per setting, the following findings were observed.

In both settings, a relevant difference between the higher and the lower performing participants was the number of turns that were conducted as a result of a
cognitive process externalized by either thinking aloud, in the case of the individual setting, or by talking to a teammate, in the case of the collaborative setting. This difference was more pronounced in the individual setting, in which higher performing participants conducted 2.6 times more cognitive-related turns than lower performing participants. In the collaborative setting higher performing dyads conducted 1.85 times more cognitive related turns. This finding was aligned with Hong & Liu’s (2003) study in which they compared novice versus expert computer game players and found that the main difference was their depth of thinking. The novice players relied mainly on trial-and-error techniques whereas expert players used strategic thinking involving tasks such as selecting, testing, classifying, comparing, analyzing, and judging.

In addition, in both settings, lower performing participants conducted ineffective turns more often than higher performing participants. On average, they conducted 2.5 times more turns that were ineffective for failing to notice information or hints on the feedback provided in the game.

In the collaborative setting, the lower performing dyads exhibited a greater frequency in communication, as measured by the total words spoken, than the higher performing dyads. In other words, the teams that used more words on average obtained the lower game scores. Similar findings have been reported related to the lack of association between the frequency in communication and the team performance (Kichuk & Wiesner, 1997; Montoya, Massey, & Lockwood, 2011). This finding indicated that the frequency of the interaction was not as important as the quality of it.

Higher performing dyads used a greater number of actively negotiated turns, meaning that the turns were played as a result of dialog or discussion between
participants and that included sharing information, elaborating a suggestion, expressing different opinions, identifying inconsistencies, and participating in the decision process. Another characteristic of higher performing dyads was that both participants were actively involved in contributing ideas and making suggestions about what to do next. On average, higher performing dyads conducted 1.84 times more turns in which both participants made at least one suggestion. This finding is aligned with the study conducted by Saab, van Joolingen, & van Houtwolters (2006) in which 29 pairs of students interacted in a microworld simulation for 90 minutes to discover the laws of physics. The authors observed that the number of proposed answers, suggestions, and generated hypotheses was correlated with the performance in solving the problems related to physics.

**Implications for Practice**

This study integrated three main areas: game-based learning, computer-supported collaborative learning, and personality psychology. Implications for practice for each of these areas are presented below.

Game-based learning remains one of the least commonly used instructional tools in online courses (Eduventures, 2010). The results of this study indicated that some instructional simulation games can be considered as an effective alternative method to complement online teaching. Instructors are thus encouraged to explore the possibility of promoting student motivation, participation, and learning by using a simulation game as part of the class. In this study, regardless of their assigned setting, the majority of the participants agreed to having enjoyed playing the DSG and considering it an effective way to learn about the DoI theory. In addition, regardless of their game performance, the
participants exhibited on average significant gains in learning after interacting with the game for 80 minutes.

If using a game for instructional purposes, it is critical to include a debriefing session since it allows learners to verify whether their assumptions were correct and provides the opportunity for instructors to clarify the learning objectives of the simulation (Peters & Vissers, 2004). Indeed, the original DSG was designed with debriefing material that instructors used to reconcile any misconception that students might have after playing. In the present study, this was made evident because after the 80-minute game session, some participants were not able to identify all of the effective strategies taught by the DoI theory and some others still had some misunderstandings about it.

Also, pre-briefing was done with the original DSG in the instructional context of a course. Students did outside readings and attended class meetings where DoI theory was discussed—prior to playing the DSG for the first time. Hence, they had some advance-organizers to guide their gameplay strategies (cf. Ausubel, 1978; van Merriënboer & Kirschner, 2007). Participants in the present study were not exposed to such pre-briefing. Reigeluth and Schwartz (1989) emphasized the importance of “instructional overlays” as being necessary for learning from games and simulations.

Results from this study indicated that without such additional overlays, participants would not learn the DoI theory very well. The average post-test mean was 9.92 and 9.47 out of 15 possible points, respectively, for the cooperative dyads and for the individual settings. If getting 95 percent correct on the post-test were used as an indicator of mastery of understanding DoI concepts and principles, the large majority of participants in the present study did not come close to mastery.
In terms of performance, collaboration in synchronous online educational games tends to be more effective when it includes elements identified by the cooperative learning theory such as positive interdependence and individual accountability. The collaboration process that lacks these structural elements can be less effective than working alone (Yetter et al., 2006). When playing the DSG collaboratively, participants had resource interdependence, award interdependence, and goal interdependence. As a result of the positive interdependence implemented in the study, 67 percent of the participants in the collaborative setting agreed or strongly agreed having felt being more committed to doing their best when playing with a teammate rather than playing alone. In this regard, one of the players made the following comment in the open ended question of the reactionnaire: “I knew that my performance ultimately affected both our standings in the chance to win some more money and I didn't want to be the player that did a bad job or held him back from being eligible for that chance. I cared more about winning for his sake.”

In the present study, it was found that participants who were more actively involved in the decision-making process and who had a higher frequency of communication, exhibited greater gains in learning. Tsay & Brady (2010) reported a similar finding after observing that students participating more actively in a team-based learning course had also obtained higher scores. Ensuring a more active participation by all team members could thus be desirable in synchronous collaborative educational games. This could be accomplished potentially by modeling the expected type of collaboration between them or by providing a mechanism through which they can monitor their own collaborative process. Zumbach, Schonemann, and Reimann (2005)
developed a text-based computer-supported learning scenario in which team members received feedback about their interaction. The authors concluded that by being able to monitoring their interaction and receiving feedback about their collaboration, further collaborative behavior was triggered and facilitated the problem-solving process.

**Limitations**

A main limitation of this study is that its findings are not generalizable to a broader population due to (1) its relative small number of participants and (2) the lack of a strict random recruitment process. The study compared two groups that included only 22 participants each. Increasing the number of participants per group could have also increased the statistical power of the study. This study is considered a quasi-experiment because even though the participants were assigned randomly to the individual or collaborative settings, their recruitment did not involve a random process.

Another limitation is that the study is not generalizable to any other contexts. The study used a specific problem-solving activity that consisted of using the Diffusion Simulation Game as the educational game instance. Each educational game has a different level of complexity, underlying instructional information, rules and mechanics, and expected outcomes. For instance, in the DSG players can take as much time as needed to discuss the most effective way to conduct a turn whereas other games might restrict players with a specific amount of time per turn thus they need to play at a faster pace.

An additional limitation of this study is that it did not measure long-term learning. The participants took the post-test immediately after playing the DSG during an 80-
minute period. They did not take another follow up test weeks later. Such a test would have allowed comparing long-term retention based on the setting assigned.

A further possible limitation was the number of statistical tests which were performed in this study, which in turn could have inflated the probability of committing a Type I error (rejecting the null hypothesis when it is actually true). However, most of the hypotheses tested in this study were based on past research and theory, and it was noted when results were inconsistent with expected findings. Since t-tests were used with two means being compared only once for the first research question, the likelihood of committing a Type I error would not be expected to have increased for these statistical tests (one test on measures of game performance and the other test for a different measure of learning gains). On the other hand, for the correlational analyses, the same variables were compared to a number of others, and the possibility of committing a Type I error could be inflated.

**Suggestions for Future Research**

There is a scarcity of studies that involve examining the implementation of collaboration learning strategies in educational games played online using verbal communication. Examining how personality traits can foster or hinder the collaboration process in these types of studies is also an area needed exploring. Here are a few suggestions for studies that could be conducted for further research in the areas of cooperative learning, personality psychology, and game-based learning:

A similar study could be conducted in a naturalistic setting instead of a controlled one. In this case, participants would be students taking a Change Management course or a related class in which they cover the topic of the diffusion of innovations theory. Students
in this naturalistic setting may be more intrinsically motivated in playing the DSG than the participants in the present study because the game is presented within the context of the class. Students could, thus, understand its applicability and usefulness as part of their professional lives. If an external motivator is needed, instead of using economic rewards, students could be offered bonus points for their participation. Optionally, instead of assigning students randomly to the individual/collaborative setting, the assignment could be done based on their personal preference.

The present study confirmed that, as predicted by several social learning theories, participants in the collaborative setting would outperform those in the individual setting in terms of game scores. Instead of focusing in comparing the performance between individuals and teams, an additional study could consist of conducting formative research to investigate ways to enhance the collaboration between participants, the game process itself, or any other element in order to promote further gains in learning. Formative research “is intended to improve design theory for designing instructional practices or processes” (Reigeluth & Frick, p. 633) and aims at identifying, through an iterative process, the best methods for attaining the most desirable outcome.

An additional study could consist of varying the number of teammates in the collaborative setting. In the cooperative learning theory, Johnson, Johnson and Holubec (1994) have identified group size as one of the factors that influence the quality of the learning outcomes and have suggested a group size of four for effective face-to-face cooperation. Since the interaction in the online environment relies completely on electronic communication media, it differs from face-to-face interaction, thus a group size of four might not be the optimal for this environment. In a study that involved 116 participants playing a computer game with different levels of difficulty, Klein (2013)
observed that the ideal group size depended on the complexity of the task: for the simplest task, individual players achieved greater performance whereas teams of two or three were optimal for more complex tasks. Klein (2013) also reported that teams of four were consistently less successful across all tasks. A new study could investigate whether Klein’s conclusions can be confirmed using the DSG.

In the present study participants played either individually or collaboratively. Those playing collaboratively the DSG for the first time took on average significantly longer than those playing it individually. A variation in this regard could consist of having all participants playing the game individually and then having all of them playing in dyads. In this way, their interaction might be richer since they could share their personal experiences from when they played it individually. An alternative variation could consist of having all participants switching settings after playing the DSG for a specific amount of time. For instance, half of them would play individually for an hour while the other half plays collaboratively and then for the next hour all participants switch settings. In this way, all of them would have experienced playing the game in both settings and they could express a more accurate opinion towards their preferred setting.

Another area of research consists of further examining the relationship between personality traits and performance when playing the DSG collaboratively. The present study controlled only for one personality trait, agreeableness. Additional studies could control for extraversion, openness to experience, and conscientiousness. Teams could be composed of individuals that have a homogeneous or heterogeneous level of any of these personality traits. This type of study could also examine the correspondence between the
personality traits and participants’ attitudes towards their learning experience using the DSG in the setting assigned.

An additional area of research could consist of exploring the effectiveness of a variety of media channels. The present study was conducted using verbal communication within Second Life. An alternative study also could include some groups using text-based chat while others use videoconferencing software. The frequency and quality of communication between those settings could then be explored.
References


and Machine: Towards an interdisciplinary learning science. (pp. 189-211).


Eduventures (2010). Trends in Instructional Tool Usage in Online Education Programs, Research Brief, Boston, MA.


Ijsselsteijn, W., De Kort, Y., and Poels, K., (In prep.). The fun of gaming: Measuring the experience of media enjoyment.


Appendix A: Content of this Study’s DSG version

Introductory message

James Whitcomb Riley Junior High School needs your help!!
As a reading specialist you're invited to conduct a federally-funded project in our school. Your mission, if you choose to accept it, is to be a change agent advocating for the effective implementation of peer-tutoring as part of all the courses.
Beware that some teachers are really opposed to any type of change!
You'd have one academic year to get all eleven teachers in our school to appreciate the instructional value of peer-tutoring and to willingly implement it as part of their daily classes.
Will you help us?

List of Activities

**Blog Post in JHS website (Cost 1 week)**
You write a blog post in the school's website about the latest studies conducted regarding the benefits of peer-tutoring, mentioning the potential positive impact on students' performance when applied appropriately.

**Demonstration (Cost 3 weeks)**
You invite all staff members into a particular teacher's classroom (an adopter's!) to see peer tutoring in action.

**Pilot Test (Cost 2 weeks)**
You attempt to influence ONE teacher by asking to let you conduct a pilot test of peer tutoring with his/her students.

**Presentation (Cost 2 weeks)**
You get on the agenda of a regularly scheduled staff meeting to explain about peer tutoring and encourage discussion about it.

**Site Visit (Cost 2 weeks)**
You select any THREE persons to visit Lighthouse School, in the next state, where an exemplary peer tutoring program is in progress.

**Talk to (Cost 1 week)**
You make a conscious effort, over a period of about one week, to engage any ONE person in a number of one to one conversations.

**Training Workshop (Cost 3 weeks)**
You conduct a hands-on in-service workshop which trains teachers in the operational details of setting up and carrying on a peer-tutoring program in their classrooms. Examples for different content areas are covered.
List of Staff Members

Principal
Very ambitious (has a 20-year plan); member of the Rotary Club and local Republican Club (active in both); delegates authority to able administrative assistants and runs a "tight ship." Has a "master's-plus" in administration.

Secretary
Has been in this school since it was built and is quite indispensable to its smooth functioning. Runs most faculty social functions

Language Arts Chairwoman
Likes her job and well she should for she has an energetic and cohesive department. Encourages inter-visitation among her teachers. She urges her teachers to develop efficient classroom management procedures.

Language Arts Teacher
A neighborhood kid who attended this school as a child and loves being back and teaching in it. Although she has certification as a reading specialist, she tends to seek and follow the advice of those on the faculty who used to be her teachers.

Math Chairman
A veteran in the school, he runs the most experienced department with a minimum of effort. Is involved much more in out-of-school activities such as the local garden club and conservation organization. Still regrets the repeal of prohibition.

Math Teacher
Just about the most respected and liked teacher in the school. Students enjoy the humorous examples he uses in teaching algebra. Exudes a sense of self-confidence and has no enemies among the staff. Serves as advisor to the Student Council. Never misses a PTA meeting.

Science Chairman
Known more for his eagerness and energy than administrative skill. He comes up with new instructional ideas faster than they can be implemented since he is working on a Master's and often tries out suggestions discussed in his graduate classes. Among older staff, he's considered somewhat erratic.

Science Teacher
Has spent years collecting specimens, preparing new instructional materials, and organizing laboratory procedures. Open to new techniques of proven value. Insists on an orderly classroom. His success in teaching makes him respected by alumni and fellow teachers.
Social Studies Chairwoman
Although competent and knowledgeable, she is head of a somewhat troubled department characterized by a high turnover rate. Most of the work, administrative and pedagogical, has to be done singlehandedly by her. Working on a Master's degree in American Studies.

Social Studies Teacher
Seen as a "male chauvinist" by some of the staff members. Spends every possible weekend hunting or fishing and is a big hockey fan. Has a resentful attitude toward the chairperson (and the middle school in general). Is working on a Master's in School Administration.

Foreign Language Teacher
Teaches Spanish, but also speaks Portuguese and French fluently. Most teachers feel comfortable around her and rely on her predictable domesticity...

Art Teacher
Feels saddled with five-thumbed, left-handed students whose talent seems to extend only as far as messing up the art room. Goes to London, Paris, and Florence every summer and has stayed at the same hotel in each city for the last 11 years.
Appendix B: Informed Consent Form

INDIANA UNIVERSITY INFORMED CONSENT STATEMENT FOR
Personality traits and performance in online Game-based learning: collaborative versus individual settings

You are invited to participate in a research study of exploring the effects of personality traits on performance and learning when playing an online strategy game either collaboratively or individually. You were selected as a possible subject because (a) you haven’t played any version of the Diffusion Simulation Game, (b) you don’t have any previous knowledge of the Diffusion of Innovations theory, (c) you are a native English speaker, and (d) you are at least 18 years old.

We ask that you read this form and ask any questions you may have before agreeing to be in the study.

The study is being conducted by Dr. Theodore Frick and Miguel Lara from Instructional Systems Technology, School of Education at IU.

STUDY PURPOSE
The purpose of this study is to explore whether pair of students playing an online instructional game collaboratively outperform students playing it individually. There will be three types of outcome measurements: game performance, knowledge acquisition, and attitudes towards the game experience. Students’ personality traits (extraversion, agreeableness, conscientiousness, emotional stability, and openness) will be collected to analyze the traits of the most successful students playing in teams and individually.

NUMBER OF PEOPLE TAKING PART IN THE STUDY:
If you agree to participate, you will be one of up to seventy five subjects who will be participating in this research.

PROCEDURES FOR THE STUDY:
If you agree to be in the study, you will do the following things:
1. Fill out a 44-item survey to measure your personality traits. The survey includes items such as: “I am someone who is talkative”. It usually takes up to five minutes to complete this survey.
2. Fill out a 10-item survey about your background and demographic information (gender, academic level, experience playing games, etc.) It usually takes up to five minutes to complete this survey.
3. Take a 15-item pre-test to measure your current knowledge about the diffusion of innovations theory. It usually takes up to thirty minutes to take the pre-test.
4. Play twice the online version of the Diffusion Simulation Game (DSG) within Second Life. You don’t need to have a Second Life account but if you do you’ll be free to use it. You will be randomly selected to play the game either individually or in pairs. If you are selected to play in pairs, you will be paired up with someone you don’t know and you will interact with your teammate just through Second Life. Your voice and computer
screen will be recorded as you play the game as part of the study analysis. Becoming familiar with the game and playing it twice will take up to two hours.

5. Take a 9-12-item survey about your experience playing the game (how much you enjoy it, etc.). It usually takes up to five minutes to complete this survey.

6. Take a 15-item post-test to measure your knowledge about the diffusion of innovations theory after playing the DSG twice. It usually takes up to thirty minutes to take the post-test.

RISKS OF TAKING PART IN THE STUDY:
While on the study, the risks and discomforts are:
· Some fatigue after using the computer for over two hours.
· The risks of completing the survey are being uncomfortable answering the questions.
· The risks of possible loss of confidentiality.

The above risks can be minimized by:
· Telling the researcher that you want to take a brief break to stretch your legs at any time while playing the game; a five minute break will be given to all participants between the two game sessions.
· Telling the researcher that you feel uncomfortable answering a particular question.
· Using pseudonyms for all the surveys that you submit online. The researcher will encrypt a file that associates your pseudonym with your real name to ensure more confidentiality.

BENEFITS OF TAKING PART IN THE STUDY:
The benefits to participation that are reasonable to expect are learning about the diffusion of innovations theory which includes several strategies to help persuade people to adopt new technologies.

ALTERNATIVES TO TAKING PART IN THE STUDY:
Instead of being in the study, you have these options: Playing the online free version of the DSG located at: https://www.indiana.edu/~simed/istdemo
You can choose not to participate.

CONFIDENTIALITY
Efforts will be made to keep your personal information confidential. We cannot guarantee absolute confidentiality. Your personal information may be disclosed if required by law. Your identity will be held in confidence in reports in which the study may be published and databases in which results may be stored. Your voice and your computer screen will be recorded but only the principal investigator and co-investigators will have access to the recordings. The recordings will be destroyed after five years. Organizations that may inspect and/or copy your research records for quality assurance and data analysis include groups such as the study investigator and his/her research associates, the Indiana University Institutional Review Board or its designees, and (as allowed by law) state or federal agencies, specifically the Office for Human Research Protections (OHRP), who may need to access your research records.

PAYMENT
You will receive payment for taking part in this study. You will receive eight dollars per hour. It is estimated that the study will take up to three hours. You will receive a partial payment of two dollars for every fifteen minutes of participation.

CONTACTS FOR QUESTIONS OR PROBLEMS
For questions about the study or a research-related injury, contact the researcher Dr. Theodore Frick at [redacted]. If you cannot reach the researcher during regular business hours (i.e. 9:00AM-5:00PM), please call the IU Human Subjects Office at (812) 856-4242 or (800) 696-2949. After business hours, please call Miguel Lara at [redacted].

In the event of an emergency, you may contact Dr. Theodore Frick at [redacted]. For questions about your rights as a research participant or to discuss problems, complaints or concerns about a research study, or to obtain information, or offer input, contact the IU Human Subjects Office at (812) 856-4242 or (800) 696-2949.

VOLUNTARY NATURE OF STUDY
Taking part in this study is voluntary. You may choose not to take part or may leave the study at any time. Leaving the study will not result in any penalty or loss of benefits to which you are entitled. Your decision whether or not to participate in this study will not affect your current or future relations with Indiana University. IRB Study # 1109006827
Appendix C: Demographic Information Survey

Demographic/Background Information Survey

Current academic level:

- Undergraduate
- Graduate

School / Department _____________

Age:

- 18 – 25
- 26 – 30
- 31 – 35
- 36 – 40
- 41 – 45
- 46 – 50
- over 50

Gender:

- Male
- Female

Is English your first languages?

- Yes
- No

How many hours per week do you play digital games?

- I don’t play digital games
- 1 to 5 hours per week
- 6 to 10 hours per week
- 11 to 15 hours per week
- More than 15 hours per week

If you do play digital games, mention the three games you play the most:

____________  ______________  ______________
How often have you used Second Life?

• I have never used it
• Less than 5 times
• Less than 20 times
• More than 20 times

Do you have any experience implementing new ideas/innovations in the work environment? Please explain.

Do you have any experience working in a school? For how long? Please describe it briefly.
**Appendix D: Big Five Inventory Personality Instrument**

John’s et al. (1990) Big Five Inventory Personality Instrument

Here are a number of characteristics that may or may not apply to you. For example, do you agree that you are someone who *likes to spend time with others*? Please write a number next to each statement to indicate the extent to which **you agree or disagree with that statement.**

<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Disagree</td>
<td>Disagree</td>
<td>Neither agree nor disagree</td>
<td>Agree a little</td>
<td>Agree strongly</td>
</tr>
<tr>
<td>Strongly</td>
<td>a little</td>
<td>nor disagree</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<p>| I am someone who… | 11. _____ Is full of energy | 12. _____ Starts quarrels with others | 13. _____ Is a reliable worker | 14. _____ Can be tense | 15. _____ Is ingenious, a deep thinker | 16. _____ Generates a lot of enthusiasm | 17. _____ Has a forgiving nature | 18. _____ Tends to be disorganized | 19. _____ Worries a lot | 20. _____ Has an active imagination | 21. _____ Tends to be quiet | 22. _____ Is generally trusting |
| 1. _____ Is talkative | | | | | | | | | | | | |
| 2. _____ Tends to find fault with others | | | | | | | | | | | | |
| 3. _____ Does a thorough job | | | | | | | | | | | | |
| 4. _____ Is depressed, blue | | | | | | | | | | | | |
| 5. _____ Is original, comes up with new ideas | | | | | | | | | | | | |
| 6. _____ Is reserved | | | | | | | | | | | | |
| 7. _____ Is helpful and unselfish with others | | | | | | | | | | | | |
| 8. _____ Can be somewhat careless | | | | | | | | | | | | |
| 9. _____ Is relaxed, handles stress well. | | | | | | | | | | | | |
| 10. _____ Is curious about many different things | | | | | | | | | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th>Statement</th>
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<tbody>
<tr>
<td>23</td>
<td>_____ Tends to be lazy</td>
</tr>
<tr>
<td>24</td>
<td>_____ Is emotionally stable, not easily upset</td>
</tr>
<tr>
<td>25</td>
<td>_____ Is inventive</td>
</tr>
<tr>
<td>26</td>
<td>_____ Has an assertive personality</td>
</tr>
<tr>
<td>27</td>
<td>_____ Can be cold and aloof</td>
</tr>
<tr>
<td>28</td>
<td>_____ Perseveres until the task is finished</td>
</tr>
<tr>
<td>29</td>
<td>_____ Can be moody</td>
</tr>
<tr>
<td>30</td>
<td>_____ Values artistic, aesthetic experiences</td>
</tr>
<tr>
<td>31</td>
<td>_____ Is sometimes shy, inhibited</td>
</tr>
<tr>
<td>32</td>
<td>_____ Is considerate and kind to almost everyone</td>
</tr>
<tr>
<td>33</td>
<td>_____ Does things efficiently</td>
</tr>
<tr>
<td>34</td>
<td>_____ Remains calm in tense situations</td>
</tr>
<tr>
<td>35</td>
<td>_____ Prefers work that is routine</td>
</tr>
<tr>
<td>36</td>
<td>_____ Is outgoing, sociable</td>
</tr>
<tr>
<td>37</td>
<td>_____ Is sometimes rude to others</td>
</tr>
<tr>
<td>38</td>
<td>_____ Makes plans and follows through with them</td>
</tr>
<tr>
<td>39</td>
<td>_____ Gets nervous easily</td>
</tr>
<tr>
<td>40</td>
<td>_____ Likes to reflect, play with ideas</td>
</tr>
<tr>
<td>41</td>
<td>_____ Has few artistic interests</td>
</tr>
<tr>
<td>42</td>
<td>_____ Likes to cooperate with others</td>
</tr>
<tr>
<td>43</td>
<td>_____ Is easily distracted</td>
</tr>
<tr>
<td>44</td>
<td>_____ Is sophisticated in art, music, or literature</td>
</tr>
</tbody>
</table>
Appendix E: Pre-/Post-Test

Suppose you are a teacher who has been hired by the school district to work at a specific junior high school. The school has the lowest academic ratings in the district. The district and you believe that if teachers start implementing Personalized Learning (tailoring curriculum, pedagogy and learning environments to meet the needs of individual learners) the academic ratings would improve considerably. Even though you were hired as a teacher, your main mission consists of making teachers realize the positive impact of Personalized Learning and to get all of them to “adopt” this instructional innovation, that is, to start implementing it by the end of the school year.

Answer the following questions using the description of the teachers and of the different activities that you could use to achieve your goal.

1. If you were to choose a staff member to do a Demonstration activity, who would be the best candidate to demonstrate the instructional innovation? (Refer to the description of Demonstration activity)

   - Principal (A)
   - Science Chairwoman (B)
   - Chemistry Teacher (D)
   - Spanish Teacher (E)
   - Visual Arts Teacher (F)

   Why?__________________________________________________________

2. At what stage of adoption should the staff member selected in the previous answer be for his or her demonstration of the innovation to be most beneficial in terms of moving other staff members forward through stages of adoption?

   ______________

3. Based on their description, which of the following staff members is a “Laggard”?

   - Principal (A)
   - Science Chairwoman (B)
   - Chemistry Teacher (D)
   - Spanish Teacher (E)
   - Visual Arts Teacher (F)
   - I don’t know what a “Laggard” is
4. Identify **THREE** adoption phases people go through before becoming adopters
   - Interest
   - Confirmation
   - Awareness
   - Trial
   - Integration
   - I don’t know the adoption phases

5. For what adoption phase would conducting a **Training Workshop** activity be **most effective**?
   - Confirmation
   - Interest
   - Awareness
   - Trial
   - Integration
   - I don’t know

6. For what adoption phase would conducting a **Site Visit** activity be **most effective**?
   - Confirmation
   - Interest
   - Awareness
   - Trial
   - Integration
   - I don’t know

7. Assume that several teachers are **not even in the first phase** of adoption of the innovation. Select **ONE** diffusion activity that would be **most appropriate** for this phase of adoption.
   - Talk to
   - Site Visit
   - Presentation
   - Training Workshop
   - Pilot Test

   Why? __________________________________________
8. Assuming that a teacher is in the last adoption phase, what would be the most likely diffusion activity to get him/her to become an adopter?
   - Presentation
   - Talk to
   - Demonstration
   - Pilot Test
   - Blog Post

   Why?___________________________________

9. Suppose that the Science Chairwoman (B) knows nothing about the innovation. What would be the most effective activity to move her closer to the adoption of the innovation?
   - Presentation
   - Talk to
   - Site Visit
   - Demonstration
   - Pilot Test

   Why?___________________________________

10. Assuming that your goal is to get all teachers to adopt Personalized Learning, what would be the very first activity that you conduct (from the list of all activities)?

   ____________________________

   Why?___________________________________

11. Assume that targeting the Principal directly does not seem to be effective. You realize that the Principal has weekly formal staff meetings with the Science Chairwoman (B) and the Social Studies Chairman (C). Also, you find out that the Principal has lunch together every weekend with the Chemistry teacher (D) and the Visual Arts Teacher (F).

Which network would you use to attempt to influence the Principal?

   - Formal staff meetings network ( A – B – C )
   - Lunchmates’ network (A – D – F)
   - I’m not sure
12. Suppose that you have not talked to any staff member yet. Who would be the best candidate to talk to first?

- Principal (A)
- Spanish Teacher (E)
- Visual Arts Teacher (F)
- Administrative Assistant (G)
- I am not sure

Why? ____________________________________________________________

13. What is the most effective approach to get all staff members to adopt the innovation?

- Taking a top-down approach (targeting the Principal and chairpersons first)
- Taking a bottom-up approach (targeting all teachers first)
- Targeting all staff members equally
- Targeting specific staff members first and then use them to influence others
- Focusing on staff members that seem reluctant to change

14. Suppose that you have been relocated to a whole new school. List the very first three steps that you would take to start your diffusion of innovation process in this new school.

15. Assume that ALL teachers are now in the FIRST phase of adoption of the innovation. Select ONE diffusion activity that would be MOST likely to move to the NEXT adoption phase a teacher who DOESN'T LIKE CHANGE in general.

- Talk to
- Blog post
- Site visit
- Presentation
- Demonstration
Staff Members

A  Principal
Very ambitious (has a 20-year plan); member of the Rotary Club and local Republican Club (active in both); delegates authority to able administrative assistants and runs a "tight ship." Has a "master's-plus" in administration.

B  Science Chairwoman
Likes her job and well she should for she has an energetic and cohesive department. Encourages inter-visitation among her teachers. She urges her teachers to develop efficient classroom management procedures.

C  Social Studies Chairman
A veteran in the school, he runs the most experienced department with a minimum of effort. Is involved much more in out-of-school activities such as the local garden club and conservation organization. Still regrets the repeal of prohibition.

D  Chemistry teacher
Has spent years collecting specimens, preparing new instructional materials, and organizing laboratory procedures. Open to new techniques of proven value. Insists on an orderly classroom. His success in teaching makes him respected by alumni and fellow teachers.

E  Spanish Teacher
Teaches Spanish, but also speaks Portuguese and French fluently. Most teachers feel comfortable around her and rely on her predictable domesticity...

F  Visual Arts Teacher
Feels saddled with five-thumbed, left-handed students whose talent seems to extend only as far as messing up the art room. Goes to London, Paris, and Florence every summer and has stayed at the same hotel in each city for the last eleven years.

G  Administrative assistant
Has been in this school since it was built and quite indispensable to its smooth functioning. Runs most faculty social functions.
Activities you can conduct:

Training Workshop
You conduct a hands-on in-service workshop which trains teachers in the operational details of setting up and carrying on a Personalized Learning program in their classrooms. Examples for different content areas are covered.

Talk to
You make a conscious effort, over a period of about one week, to engage any ONE person in a number of one to one conversations.

Site Visit
You select any three teachers to visit Lighthouse School, in the next state, where an exemplary Personalized Learning program is in progress.

Presentation
You get on the agenda of a regularly scheduled staff meeting to explain about Personalized Learning and encourage discussion about it.

Pilot Test
You attempt to influence one teacher by asking to let you conduct a pilot test of Personalized Learning with his/her students.

Demonstration
You invite all staff members into a particular teacher's classroom (an adopter's!) to see Personalized Learning in action.

Blog Post in JHS website
You write a blog post in the school's website about the latest studies conducted regarding the benefits of Personalized Learning, mentioning the potential positive impact on students' performance when applied appropriately.
Appendix F: Team Setting Reactionnaire

Game experience perception

1. The game was difficult.
   - Strongly Disagree
   - Disagree
   - Neutral
   - Agree
   - Strongly Agree

2. I enjoyed playing the game.
   - Strongly Disagree
   - Disagree
   - Neutral
   - Agree
   - Strongly Agree

3. The game interface was confusing.
   - Strongly Disagree
   - Disagree
   - Neutral
   - Agree
   - Strongly Agree

4. The game does not reflect reality.
   - Strongly Disagree
   - Disagree
   - Neutral
   - Agree
   - Strongly Agree

5. If given the chance, I would like to play the game more.
   - Strongly Disagree
   - Disagree
   - Neutral
   - Agree
   - Strongly Agree

6. I think playing the game was an effective way to learn.
   - Strongly Disagree
   - Disagree
   - Neutral
   - Agree
   - Strongly Agree

Teamwork perception

1. I enjoyed playing the DSG with the teammate I was assigned.
   - Strongly Disagree
   - Disagree
   - Neutral
   - Agree
   - Strongly Agree

2. I would have achieved better results if I had played the DSG alone.
   - Strongly Disagree
   - Disagree
   - Neutral
   - Agree
   - Strongly Agree

3. As a team, we generated more and better ideas to get more adopters than I could have done alone.
   - Strongly Disagree
   - Disagree
   - Neutral
   - Agree
   - Strongly Agree
4. I felt more motivated playing the DSG as part of a team than if I had played alone.
   Strongly Disagree  Disagree  Neutral  Agree  Strongly Agree

5. I was able to learn more concepts and understand effective strategies related to the diffusion of innovations by working with my teammate.
   Strongly Disagree  Disagree  Neutral  Agree  Strongly Agree

6. I like the personality of the teammate I was assigned to play the DSG.
   Strongly Disagree  Disagree  Neutral  Agree  Strongly Agree

7. If I were to play the DSG again, I would prefer playing it just by myself.
   Strongly Disagree  Disagree  Neutral  Agree  Strongly Agree

8. Playing the game with somebody else was the most effective way to learn from the gaming experience.
   Strongly Disagree  Disagree  Neutral  Agree  Strongly Agree

9. I felt I was more committed to do my best when playing with a teammate than if I had played alone.
   Strongly Disagree  Disagree  Neutral  Agree  Strongly Agree
Appendix G: Individual Setting Reactionnaire

Attitudinal Survey for participants in individual setting

Game experience perception

1. The game was difficult.
   Strongly Disagree  Disagree  Neutral  Agree  Strongly Agree

2. I enjoyed playing the game.
   Strongly Disagree  Disagree  Neutral  Agree  Strongly Agree

3. The game interface was confusing.
   Strongly Disagree  Disagree  Neutral  Agree  Strongly Agree

4. The game does not reflect reality.
   Strongly Disagree  Disagree  Neutral  Agree  Strongly Agree

5. If given the chance, I would like to play the game more.
   Strongly Disagree  Disagree  Neutral  Agree  Strongly Agree

6. I think playing the game was an effective way to learn.
   Strongly Disagree  Disagree  Neutral  Agree  Strongly Agree

Individual game play experience perception

1. I feel that I would have been more motivated playing this game with somebody else instead of playing it alone.
   Strongly Disagree  Disagree  Neutral  Agree  Strongly Agree

2. I could have performed better in the game if I had played with a teammate (another player in Second Life) instead of playing by myself.
   Strongly Disagree  Disagree  Neutral  Agree  Strongly Agree
3. If I had to play the game again, I would prefer keep playing it alone than with a remote teammate.

<table>
<thead>
<tr>
<th>Strongly Disagree</th>
<th>Disagree</th>
<th>Neutral</th>
<th>Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
</table>

4. I believe I can learn more effective strategies about getting people to adopt an innovation by playing the game individually than with a remote teammate.

<table>
<thead>
<tr>
<th>Strongly Disagree</th>
<th>Disagree</th>
<th>Neutral</th>
<th>Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
</table>
*Discuss: In this context, discussion includes:
   a) Providing a different opinion/suggestion
   b) Mentioning reasons why the proposed suggestion could or could not work
   c) Identifying additional actions that could take place after conducting the proposed activity
   d) Proposing selecting a specific staff member
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