

Designing an Educational Game with *Ten Steps to Complex Learning*

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This dissertation is dedicated to my grandparents, Frankie and David Enfield, and my father, Phillip Enfield. I owe my competitive spirit and interest in games to them, which was fostered through our endless hours spent playing card games. Throughout my life, their unyielding pride in me, their complete trust in my choices, and their faith in my abilities gave me the confidence to pursue my dreams. They will always be in my heart.

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Designing an Educational Game with *Ten Steps to Complex Learning*

Few instructional design (ID) models exist which are specific for developing educational games. Moreover, those extant ID models have not been rigorously evaluated. No ID models were found which focus on educational games with complex learning objectives.

Ten Steps to Complex Learning (TSCL) is based on the four component instructional design (4C/ID) model (van Merriënboer & Kirschner, 2007). However, the TSCL was not created specifically for educational games, nor were any studies found in which the TSCL has been used in this way. The primary focus of this study was to investigate the applicability of the TSCL for educational game design and how it might be improved for this purpose.

Formative research methods were used to investigate the redesign of the Diffusion Simulation Game (DSG). When the original digital version of the DSG was played outside a formal classroom context with no instructional support, players were often overwhelmed by the complexity of applying diffusion strategies to persuade individuals to adopt an innovation. Thus, the DSG appeared to be a good candidate for redesign following the TSCL. Six rounds of formative research were conducted which included iterative design, development, evaluation and reflection.

The TSCL provided fundamental guidance in initial stages of redesigning the DSG. Eight additional scenarios were developed and grouped into three task classes arranged in increasing complexity. However, the TSCL by itself was not sufficient.

Guidance was found to be lacking on how to provide supportive and procedural information in a digital game environment, and on how to address strongly held player beliefs that contradicted their game experience. The unique, detailed design case in this study also contributes an important precedent for developing educational games.

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Chapter 1: Introduction

Over the past 40 years, video and computer games have emerged to become one of the most pervasive, profitable, and influential forms of entertainment in the United States and across the world (Squire, 2003). According to the Entertainment Software Association (ESA), the U.S. interactive entertainment software publishing industry sold over 273 million computer and video games in 2009, leading to \$10.5 billion in revenue (ESA, 2010). Another indicator of the popularity of games in the United States is that, in 2009, 67 percent of American households played computer and/or video games (ESA, 2010).

Many researchers believe that the inherent ability of entertainment games to highly engage players can be harnessed to engage learners in educational games. For example, Shaffer, Squire, Halverson and Gee (2005) ask “how can we use the power of video games as a constructive force in schools, homes, and at work?” (p. 105). However, even if games are capable of increasing the motivation and engagement of learners, instruction should be designed effectively so that learners are more likely to meet the learning objectives of the game. Many Instructional Design (ID) theories exist which prescribe how and when instruction should be provided to improve the likelihood that desired learning will occur. However, most ID theories have not been thoroughly tested and therefore have potential to be improved (Reigeluth & Frick, 1999). Prescriptions being offered by theorists and researchers should be validated repeatedly and with a variety of situations (such as with the design of educational games) so that the effectiveness and generalizability of the model is understood. “At the very least [ID

theories] can all benefit from more detailed guidance for applying their methods to diverse situations” (Reigeluth & Frick, 1999, p. 633).

Which ID theory is most appropriate for the design of educational games? Likely, the best prescription to follow will depend on various factors including the nature of the learning that is involved. Reigeluth and Schwartz (1989), for example, distinguish between the learning of knowledge, processes, procedures, and causal principles. The complexity of what is being learned is another factor that may influence which ID theories may be most useful for designing a particular educational game. In this study, for example, the nature of what is to be learned through gameplay justifies the use of an ID theory which lessens the cognitive load of the learners to support complex learning objectives. Still another factor important in the selection of an appropriate ID theory regards the design expertise and work style of the game designers and/or instructional designers involved.

Since the simple but addictive video game Pong was released in 1972, video and computer games have become capable of modeling much more complex games with a large number of interrelated variables. Often, there is no one correct way to win, or even to play, a digital game. As computer processing power continues to increase and the development tools for creating complex environments become more advanced, so does the potential for providing environments that can support complex learning.

The Four-Component Instructional Design (4C/ID) Model developed by van Merriënboer provides a structure to support instruction for complex learning in ill-structured domains (van Merriënboer & Kirschner, 2007). While ID models are concerned with how and when instruction should be provided, ID theories are concerned

with the process teachers and other instructional designers should use to design the instruction (Reigeluth, 1999). The 4C/ID Model provides instructional designers with a blueprint for designing instruction which facilitates complex learning.

The 4C/ID Model is consistent with Cognitive Load Theory (CLT). “Application of CLT prevents cognitive overload and (equally important) frees up processing resources that can be devoted to learning” (van Merriënboer, Kirschner, & Kester, 2003, p. 23). The 4C/ID Model provides a general framework for designers to follow when designing instruction for complex learning. It emphasizes the use of authentic, holistic learning tasks sequenced from simple to complex. Learning is promoted through supportive information, procedural information, and part-task practice. Van Merriënboer and Kirschner (2007) provide the *Ten Steps to Complex Learning* (TSCL) ID theory as a more step-by-step prescription for designing instruction based on the 4C/ID Model.

Problem Statement

Educational game designers, particularly novices, may benefit from ID theories that offer a prescription of how to design a game to be effective in meeting its learning objectives as well as appealing to play. The TSCL may be particularly useful to educational game designers in designing educational games which have complex learning objectives. However, a literature review provided no cases in which the application of the TSCL to educational games had been studied nor did it reveal any alternative educational game design models which are intended to support complex learning.

Purpose

The primary purpose of the study was to investigate the TSCL in its application to digital games which have complex learning objectives. This investigation was expected to lead to tentative suggestions for improvements to the TSCL in its application to educational games. To study the application of the TSCL, the ten steps were applied to a design of an educational game — the re-design of the Diffusion Simulation Game (DSG). Playing the DSG successfully requires application of strategies for diffusion of an innovation at appropriate times in order to gain adopters. To do so successfully requires complex learning. The TSCL was selected to guide the re-design of the DSG because of its focus on instructional design (important for educational games) and its focus on promoting complex learning (important for the nature of what is to be learned from playing the DSG).

A secondary purpose of the study was to provide educational game designers a design case in which an ID theory is applied to the design of an educational game. What is a design case? According to Boling (2010, p. 2), “At heart, the design case is a description of a real artifact or experience that has been intentionally designed.” She explains that the primary goal of a design case is to provide designers with precedent – defined by Oxman as “the unique knowledge embedded in a known design” (qtd. in Boling, 2010, p.2). She further explains that expert designers have a huge amount of precedent which may be useful in future designs when the designer chooses to use an affordance of a prior solution. As with all designers, educational game designers may use design cases to increase their precedent. Educational game designers therefore would benefit from a design case which applies an ID theory to the design of an educational

game. In this paper, the term *case* refers to the specific instance of the application of the TSCL to the DSG (the case study) while the term *design case* refers to the description of the designed product and the design decisions that were made in creating the game.

Pragmatic Significance

The application of the TSCL to the re-design of the DSG was expected to result in a new version of the DSG which would be more effective in meeting its learning objectives and less dependent on external instructional support than the current version. However, this study was **not** an evaluation of the DSG. Improving the DSG was only a side effect of completing the study. In regards to this study, the reason for re-designing the DSG was to explore how the TSCL can be applied to improve the DSG's appeal, effectiveness, and efficiency. By doing so, the author sought insight into how the TSCL may be improved to be effectively applied to the design of other digital games which have complex learning objectives. Lastly, a thick, rich description of the design process and design decisions is provided for educational game designers as a precedent in which an ID theory guided the design of an educational game.

Chapter 2: Literature Review

The literature review is organized into eight sections. (1) *Complex learning* is defined and discussed. (2) ID theories are described in relation to learning theories. (3) Three particular ID theories (Merrill's First Principles of Instruction, Reigeluth's Elaboration Theory, and van Merriënboer's 4C/ID Model) are used to illustrate principles of instruction that promote complex learning. (4) Methods for managing cognitive load are discussed. (5) A more detailed description of the 4C/ID Model is provided. (6) The *Ten Steps to Complex Learning* (TSCL) ID theory is introduced as a more specific prescription of the 4C/ID Model and discussed. (6) An argument for the potential of games to invoke high levels of engagement is given. (7) Game-based learning (GBL) is discussed; addressing the features of educational games that make them engaging to players and promote learning. (8) Research on the application of ID theories to the design of educational games is reviewed and the areas that need further research are identified. The literature review concludes by restating the purpose of the study and identifying the research questions that will guide the study.

Complex Learning

Complex learning involves the learning of how to complete authentic tasks which require the use and integration of knowledge and skills from multiple domains. Complex learning tasks have no single correct method of completion but instead a range of methods that result in the completion of the task at varying degrees of appeal, efficiency, and effectiveness. Van Merriënboer and Kirschner (2007) state that "complex learning involves the integration of knowledge, skills and attitudes; the coordination of

qualitatively different *constituent skills*, and often the transfer of what is learned... to daily life...” (p. 4).

A fundamental aspect of complex learning is the integration and coordination of the constituent skills needed to perform a task. Complex learning “has little to do with learning separate skills in isolation, but it is foremost dealing with learning to coordinate and integrate the separate skills that constitute real-life task performance. Thus, in complex learning the whole is clearly more than the sum of its parts because it also includes the ability to coordinate and integrate those parts.” (van Merriënboer, Clark, & de Croock, 2002, p. 40).

For example, complex learning is required in order to become an effective teacher. To be effective, teachers must have knowledge of human development, instructional technology, teaching methods, and the content knowledge in which they teach. They need to be skilled in administrative tasks and in communication with colleagues, students, and parents. They must address the social and emotional needs of their students. All of this knowledge and all of the skills of the teacher in these domains must be integrated well. A teacher with high content knowledge and no social skills would be largely ineffective as a teacher. Likewise, a teacher who is skilled at providing instruction using effective methods but has little understanding of the subject matter they are teaching would not be effective. Not only is it important to have knowledge and skills in multiple domains, it is important that they integrate the knowledge and skills well as to provide sufficient support to children in all areas. Balancing all of the responsibilities and performing the tasks effectively and efficiently is a result of complex learning.

The need for complex learning is not likely to subside. “The nature and skills needed for currently available jobs are rapidly changing while the information relevant to carrying out those jobs quickly becomes obsolete. This poses higher demands on the workforce with employers stressing the importance of problem solving, reasoning, and creativity to ensure that employees can and will flexibly adjust to rapid changes in their environment” (Merriënboer & Kirschner, 2007, p. 5). Because complex learning is and will remain important in most careers, particularly in the information-age; attention is being given to how it can be supported. In fact, multiple ID theories have been proposed to support complex learning.

ID Theories, Learning Theories, and ISD Processes

ID theories offer prescriptions for which *methods* of instruction should be used in which *situations* (Reigeluth, 1999). Learning theories (which describe how learning occurs) differ from ID theories (which prescribe how and when instructional methods should be used). While learning theories are descriptive in nature, ID theories are prescriptive in nature. The idea behind an ID theory is that, if people learn in a particular way, instruction should be provided to support learning in that way. An ID theory generally states that the probability of learning is higher if instruction is provided in a particular way than if it is not.

To verify and improve on ID theories, they should be tested in a variety of situations. “At the very least [ID theories] can all benefit from more detailed guidance for applying their methods to diverse situations” (Reigeluth & Frick, 1999, p. 633).

The field of Instructional Systems Technology is often concerned with developing and improving Instructional Design (ID) theories and Instructional Systems Design (ISD) processes (also referred to as ID models). While ID theories prescribe how and when instructional methods should be used, ISD processes are concerned with what “a teacher or instructional designer should use to plan and prepare for the instruction” (Reigeluth, 1999, p. 13). While ID theories focus on what instruction should look like, ISD processes focus on how to create that instruction.

ID theories and ISD processes are prescriptive and probabilistic (Reigeluth, 1999). They are prescriptive because they provide *prescriptions* for how and when instruction should be provided (for an ID theory) or for how instruction should be effectively designed (for an ISD process). They are probabilistic because they *increase the probability* (but do not guarantee) that learning will be promoted if instruction is provided according to the ID theory or designed following the ISD process. These terms may be convoluted and are sometimes used interchangeably due to systematic ambiguities. This may be because ID theories often include elements of ISD processes (also called ID models) and vice versa.

In summary, learning theories (which describe how learning occurs) inform ID theories (which prescribe how and when instructional methods should be used) which inform ISD processes/ID models (which prescribe a process for how instruction should be designed).

Principles of Effective Instruction for Complex Learning

Current ID theories which are intended to promote complex learning share fundamental principles. The principles (use of authentic tasks, use of whole tasks, simple-to-complex sequencing of tasks, and some form of supportive information) are illustrated below using three ID theories which are currently popular in the field of IST. Table 1 provides the name of the theories and some of the seminal publications related to each, as well as the number of articles available from Google Scholar which cited each publication as of July. 11, 2012 (Google Scholar, 2012).

Table 1: *Popular ID Theories in IST*

ID theory	Publication (<i>full APA citation in reference list</i>)	Citations
Elaboration Theory	Reigeluth, C.M. (1999). The elaboration theory: Guidance for scope and sequence decisions.	202
First Principles of Instruction	Merrill (2002). First Principles of instructional design.	824
Four Component Instructional Design Model	van Merriënboer, Kirschner, & Kester (2003). Taking the load off a learner's mind: instructional design for complex learning.	408
	van Merriënboer & Kirschner (2007). Ten steps to complex learning: A systematic approach to four-component instructional design.	197

Authentic Tasks

A fundamental principle of ID theories aimed at designing instruction for complex learning is to provide learners with authentic tasks. Authentic tasks are tasks that “have real-world relevance and utility, that integrate those tasks across the

curriculum, that provide appropriate levels of complexity, and that allow students to select appropriate levels of difficulty or involvement” (Jonassen, 1992, p. 140). For the purpose of designing instruction, authentic tasks involve the learner in solving complex, real-world problems.

“The general assumption is that such tasks help learners to integrate the knowledge, skills, and attitudes necessary for effective task performance; give them the opportunity to learn to coordinate constituent skills that make up complex task performance; and eventually enable them to transfer what is learned to their daily life or work settings. This focus on authentic, whole tasks can be found in practical educational approaches, such as project-based education, the case method, problem-based learning, and competency-based learning; and in theoretical models, such as Collins, Brown, and Newman’s (1989) theory of cognitive apprenticeship learning, Jonassen’s (1999) theory of constructive learning environments, Nelson’s (1999) theory of collaborative problem solving, and Schank, Berman, and MacPerson’s (1999) theory of goal-based scenario” (van Merriënboer et al., 2003, p. 5).

Merrill (2002) notes that “Problem-centered learning is well represented by a number of recent instructional models including: Collins, Brown and Newman (1989), *Cognitive Apprenticeship*; Schank, Berman, and Macperson (1999), *Goal Based Scenarios*; Jonassen (1999), *Constructivist Learning Environments*; Savery and Duffey (1995), *Problem-Based Learning*; Clark and Blake (1997), *Novel Problem Solving*; and van Merriënboer (1997); *Whole Task Practice in 4C/ID Model*.” (p. 45). An and Bonk (2009) describe the importance of problem-driven activities in game-based learning (GBL):

“Like most good games, digital game-based learning environments should provide a set of complex, holistic, and challenging problems. When effectively designed and implemented, such problems help structure the entire learning experience around problem solving so that learners learn to think critically and work with information and resources to solve problems rather than simply memorizing facts (Gee, 2007; Squire, 2005a, 2005b)” (p. 44).

Merrill's First Principles of Instruction is an ID theory which is centered on learners solving problems. Merrill (2002) notes that the learning task should represent the task that the learner will encounter in the real world following instruction (the task should be authentic). He identified the First Principles of Instruction by analyzing a variety of design theories and models and defined a *principle* as “a relationship that is always true under appropriate conditions regardless of program or practice”. The first of Merrill's five principles states that “Learning is promoted when learners are engaged in solving real-world [authentic] problems” (Merrill, 2002, p. 45). The other four principles represent “four distinct phases of learning: (a) activation of prior experience (b) demonstration of skills (c) application of skills (d) integration of these skills into real-world activities” (Merrill, 2002, p. 44). Figure 1 illustrates these four phases being centered on the task of solving an authentic problem.

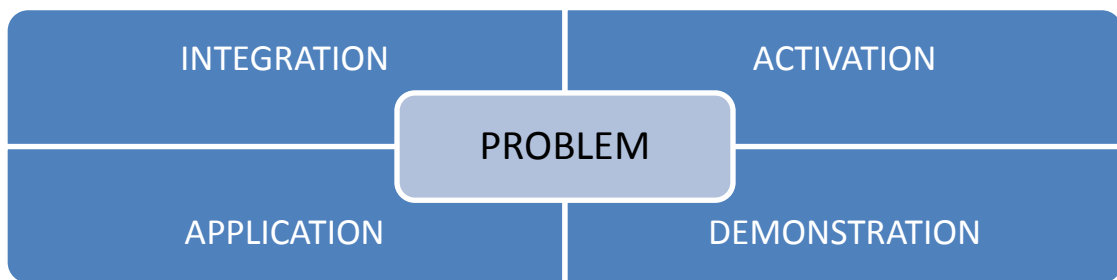


Figure 1. First Principles of Instruction. From First Principles of Instruction (p. 45), by M.D. Merrill, 2002, Educational Technology, Research and Development, 50, 43-59. Reprinted with permission.

Van Merriënboer and Kirschner's (2007) *Four-Component Instructional-Design* (4C/ID) model is another ID theory that is currently popular in the field of Instructional Design which is grounded on the use of authentic tasks. They propose that “Simulated task-environments must allow the performance of realistic, authentic tasks right from the

beginning of the training program” (van Merriënboer & Kirschner, 2007, p. 43). They characterize real-life problems as ill-structured, which is a term used by other researchers in the field.

“Simon (1973) characterized ill-structured problems as problems that go further than one specific area, often including important social, political, and scientific problems. Voss (1988) adds that in order to resemble situations in the real-world, ill-structured problems have both unclear goals and incomplete information. Finally, ill-structured problems often have no correct answer, but rather a number of possible answers that are more adequate or less adequate than others” (van Merriënboer & Kirschner, 2007, p. 42).

Van Merriënboer and Kirschner go on to state that [authentic] learning tasks can be performed in a “real” environment or through a simulated environment. They note that simulated environments are preferred for many learning tasks, such as when:

1. The task is difficult to provide to learners in real life.
2. Necessary support for learners is difficult or impossible to provide in real life.
3. The task may lead to injury or loss of life.
4. The task may lead to the inefficient use of resources (e.g. time, money, materials).
5. The real-world task may lead to a level of detail and stress that interferes with learning.

According to van Merriënboer and Kirschner (2007), “it is often worthwhile to use simulated task environments that offer a safe and controlled environment where learners may develop and improve skills through well-designed practice” (p. 43). In addition, simulations may be much more cost effective than real-life situations because they may save valuable resources and because of their ability to condense time and space, providing learners with many trials in a range of (simulated) locations and in a relatively short amount of time.

Furthermore, simulations provide an experiential learning environment where learners can use trial and error with minimal or no consequences for failure. The idea of *failing forward* in games (also applicable to simulations) was discussed in an interview held in the virtual environment—second life (Masie, 2006). In the world of gaming, intermediate failure is not considered as something bad, but instead as a step on the way to winning. “This has huge implications for learning. If you are learning how to fly an airplane, you can crash several times. Each time, you may be sad you failed, but other than the momentary emotion, you won’t face any negative consequences. You can fail forward. In other words, you can fail until you succeed” (Masie, 2006, p. 35).

In summary, providing authentic, real-world, problem-based tasks is believed to be important in promoting complex learning. Additionally, for the reasons described above it is often preferred to provide learners a simulated version of an authentic task instead of a real-world task.

Whole Tasks

Another widely accepted principle of many ID theorists is that learners should be provided with whole-task activities — not incomplete parts of a whole task.

Merrill (2002), for instance, defined a *problem* to “...include a wide range of activities, with the most critical characteristics being that the activity is some whole task rather than only components of a task...” (p. 45).

Van Merriënboer and Kirschner (2007) also discuss the importance of taking a holistic approach to learning tasks. They explain that often, an atomistic approach is taken to ID. This approach involves breaking a learning goal into its most simple

elements and identifying learning objectives for the learner to meet to ensure they have learned each of these elements. The atomistic approach works well when there are few interactions between elements, but not if the elements are closely interrelated. In more complex situations which involve many interactions between elements, learners need to see the whole to gain an understanding of how the individual elements are interrelated. Providing learners with whole learning tasks is preferred in these more complex situations. According to van Merriënboer and Kirschner, holistic approaches offer a solution for three problems which arise from using atomistic approaches — compartmentalization, fragmentation and the transfer paradox.

Compartmentalization is the separation of a whole into distinct categories. ID theories often focus on one particular domain of learning such as the cognitive, the affective, or the psychomotor domain. Further distinctions are made in particular domains. In the cognitive domain, which is often the most emphasized domain in ID theories, a distinction can be made between models for declarative learning and models for procedural learning. Distinctions can be made based on the nature of what is being learned as well. For example, the ID theory for simulations proposed by Reigeluth and Schwartz (1989) made a distinction between the learning of procedures, the learning of processes, and the learning of causal principles. According to van Merriënboer and Kirschner (2007), these forms of compartmentalization are not preferred for complex learning. They argue that “it makes little sense to distinguish domains of learning for professional competencies” (p. 7) by asking the question of whether a patient in a hospital would prefer a surgeon with great technical skills [psychomotor domain] or one with comprehensive knowledge of the human body [cognitive domain]. Logically, the

surgeon should have both and should be able to apply both in an integrated fashion.

Holistic design models for complex learning aim at the integration of these domains.

Another issue which arises when an atomistic approach to Instructional Design is taken is fragmentation. Fragmentation is the “process of breaking something into small, incomplete or isolated parts” (van Merriënboer & Kirschner, 2007, p. 7). Traditional ID theories used fragmentation as their base technique. These theories typically divided a learning task into distinct learning or performance objectives and then prescribed instructional methods which are suitable for reaching each particular objective. For complex skills, the objectives are provided in sequence to the learner as part-task activities. “Thus the learner is taught only one or a very limited number of constituent skills at a time. New constituent skills are gradually added, and it is not until the end of the instruction – if at all – that the learner has the opportunity to practice the whole complex skill” (van Merriënboer & Kirschner, 2007, p. 8). Holistic ID theories for complex learning aim at the coordination of performance objectives so that learners can transfer what they have learned to the tasks they will encounter in real-life.

The last problem of taking an atomistic approach to Instructional Design discussed by van Merriënboer and Kirschner (2007) involves the *Transfer Paradox*. The transfer paradox is the phenomenon of “the methods that work the best for reaching isolated, specific objectives are often not the methods that work best for reaching integrated objectives and increasing transfer of learning” (van Merriënboer & Kirschner, 2007, p. 9). Therefore, holistic approaches to ID are directed toward more general objectives that go beyond a limited list of highly specific objectives.

Providing whole tasks to learners is believed to be important for complex learning. Still, scaffolding learning so that novices can incrementally gain understanding of a complex problem needs to occur. If compartmentalization and fragmentation is not being used to simplify problems for learners, how can complex problems be simplified so that novices are more likely to learn? One strategy to scaffold learning within whole tasks is to sequence the learning tasks from simple to complex.

Simple to Complex Sequence of Tasks

Elaboration Theory is an ID theory developed by Charles Reigeluth which extends from David Merrill's Component Display Theory. The most fundamental principle of Elaboration Theory is the simple-to-complex sequencing of lessons. The Elaboration Theory of Instruction prescribes that instruction start with an epitome lesson — instruction for the one or two most fundamental and simple principles at the application level. “The remainder of the instruction presents progressively more detailed ideas, which elaborate on earlier ones” (Reigeluth & Stein, 1983, p. 338).

The 4C/ID Model offered by van Merriënboer and Kirschner (2007) also employs the simple-to-complex construct. The tasks that are designed require mental models of varying complexity, depending on how complex the task is. Tasks which require the same mental model are grouped in a single task class. The 4C/ID Model prescribes the task classes (the groups of tasks which require the same mental model) to be sequenced progressively from the simplest to the most complex task class. This allows the learner to gradually build their mental model so that they are not overwhelmed by the complexity of

a task that requires a very complex mental model without having sufficient support in building the model.

Direct Guidance

The use of whole, authentic tasks does not necessarily equate to providing minimal guidance to the learner. Kirschner, Sweller, and Clark (2006) discuss the debate between those who believe that learners should be provided direct instruction and those who believe learners should discover concepts and procedures for a particular discipline with minimal or no guidance. They provide an argument based on human cognitive architecture and on prior research for the use of direct guidance over the minimal guidance approach embraced by constructivist, discovery, problem-based, experiential, and inquiry-based teaching. Kirschner et al. believe that the use of direct guidance over minimal guidance approaches to learning is particularly important for novice learners.

To provide learners more than minimal guidance, various methods are available including direct instruction, modeling, scaffolding, prompts, and natural and artificial feedback. One of Merrill's five principles, *demonstration*, is a method of direct instruction and modeling which provides guidance to learners. Through demonstration, learners are able to see how to do something correctly without having to discover it on their own. Merrill's activation phase also provides the learner with guidance. Likewise, the corrective feedback in the application phase is a form of guidance.

The 4C/ID model uses a combination of fading of instructional support and demonstration to promote complex learning. Learners are provided with a *worked-out example* which includes much instructional support (direct guidance) followed by further

learning tasks in which the support is gradually faded. This fading of instructional support provides the scaffolding that learners need in order to become able to complete the task independently, with no instructional support.

Managing Cognitive Load using the 4C/ID Model

Though there is a consensus among many current researchers that complex learning is promoted through the use of authentic, holistic learning tasks that are based on real-life tasks as the driving force for learning; van Merriënboer et al. (2003) point out that “a severe risk of all of these approaches is that learners have difficulties learning because they are overwhelmed by the task complexity” (p. 5).

Four-Component Instructional-Design (4C/ID) provided by van Merriënboer et al. (2003) is grounded on Cognitive Load Theory (CLT) and is useful in managing cognitive load while maintaining a whole-task approach to complex learning. 4C/ID can be viewed as an ID theory or an ID model. As an ID model, 4C/ID provides a prescription for what should be done to manage cognitive load and support learning *during* instruction. As an ID theory, 4C/ID informs what a teacher or instructional designer should plan and prepare *prior to* instruction. The basic assumption that forms the basis of the 4C/ID Model is that blueprints for complex learning can always be described by four basic components (van Merriënboer et al., 2003). The four components are:

1. *Learning Tasks* are simplified versions of the whole-task. Each task is in a *task class* with other tasks that can be accomplished using the same mental model.

Tasks in a task class move from having many scaffolds (worked-out examples) to having no support (conventional problems).

2. *Supportive Information* makes up the mental model needed for completing the tasks. This information is provided prior to the tasks and available for review during the tasks. Supportive information is typically more complex than procedural information and requires logic and problem solving.
3. *Procedural information* provides learners with “how-to” algorithms. Procedural information is typically less complex and is provided as just-in-time information at the moment the learner needs it. Such information does not need to be memorized, so Cognitive Load is reduced by only presenting it when the learner has an immediate need to use it.
4. *Part-task practice* is information that must be learned at a high degree of automaticity. It is provided when the whole task does not provide sufficient practice/repetition of a part of the task that needs to be automated by the learner.

Van Merriënboer et al. provide a “schematic representation of a training blueprint for complex learning that is fully consistent with CLT [Cognitive Load Theory]” (van Merriënboer et al., 2003, p. 11). The schematic, re-printed in Figure 2, offers a visualization of the four components which make up the 4C/ID Model: simple-to-complex whole-task practice, just-in-time supportive information, just-in-time procedural information, and part-task practice.

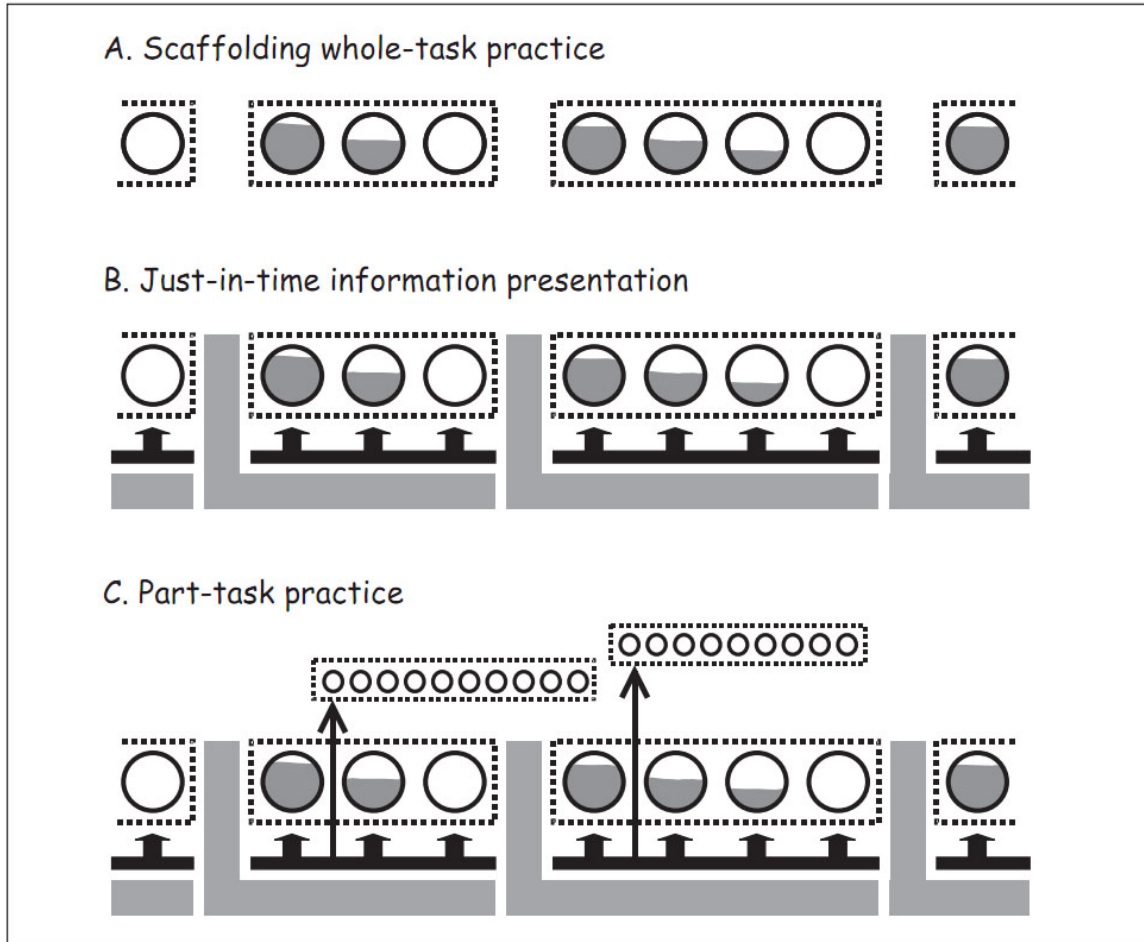


Figure 2: Schematic representation of a training blueprint for complex learning that is fully consistent with CLT. From EDUCATIONAL PSYCHOLOGIST, 38(1), 5–13, Taking the Load Off a Learner’s Mind: Instructional Design for Complex Learning (p. 11), by J.J.G. van Merriënboer, P.A. Kirschner, & L. Kester, 2003, Mahwah, NJ: Lawrence Erlbaum Associates, Inc. Copyright 2003 by Lawrence Erlbaum Associates, Inc.—Reprinted with permission.

Scaffolding Whole-Task Practice

Providing novice learners highly complex learning tasks from the start of a course or training program would “result in excessive cognitive load for the learners, with negative effects on learning, performance, and motivation (Sweller, van Merriënboer, & Paas, 1998)” (van Merriënboer et al., 2003, p. 6). The approach used by this framework to address this issue is to initially provide learners simple learning tasks and, as their

skills improve, provide tasks with increasingly higher complexity. To be consistent with holistic approaches, all tasks from the simplest to the complex should be whole-tasks.

The portion of the schematic for *scaffolding whole-task practice* (Figure 3) represents the first component of 4C/ID — simple-to-complex whole-task practice.



Figure 3. Scaffolding Whole-Task Practice. From EDUCATIONAL PSYCHOLOGIST, 38(1), 5–13, *Taking the Load Off a Learner's Mind: Instructional Design for Complex Learning* (p. 11), by J.J.G. van Merriënboer, P.A. Kirschner, & L. Kester, 2003, Mahwah, NJ: Lawrence Erlbaum Associates, Inc. Copyright 2003 by Lawrence Erlbaum Associates, Inc.—Reprinted with permission.

The dotted rectangles represent an ordered sequence of task-classes and the circles represent the whole-tasks that make up a task class. Each task-class contains learning tasks that require the same body of knowledge (or mental model) to successfully complete the task. The task classes are sequenced from simple to complex. The learning tasks (circles) within the same task class (dotted rectangles) have a degree of variability to support transfer of learning to new situations.

The shaded area within the circles of the diagram represents the amount of support present for each whole-task. Note how the amount of support fades within each task class, a process called scaffolding.

“Scaffolding explicitly pertains to a combination of performance support and fading. Initially, the support enables a learner to achieve a goal or action not achievable without that support. When the learner achieves the desired goal, support gradually diminishes until it is no longer needed. Because excessive or insufficient support can hamper the learning process, it is critical to determine the right type and amount of support and to fade at the appropriate time and rate. Coaching by providing hints, prompts, and feedback; modeling the use of cognitive strategies by thinking aloud; presenting cue cards, checklists, and process worksheets; asking leading questions; and giving part of a solution are all examples of such support” (van Merriënboer et al., 2003, p. 5).

The amount of support in the first task of each task class is very high. This almost fully-shaded circle represents a *worked-out example* and is equivalent to the demonstration phase of the First Principles of Instruction which requires the learner only to observe the problem being solved. Subsequent tasks in a task class provide less and less scaffolding, requiring the learner to perform more and more of the task independently until finally, in the last whole-task of the task class, learners complete the task on their own with no support. This almost completely un-shaded circle represents a *traditional problem*—a problem the learner is expected to solve with no support by applying learned knowledge and skills.

Just-in-Time Information

The portion of the schematic for *just-in-time information presentation* (Figure 4) incorporates the second and third components of 4C/ID — supportive and procedural information, respectively. Note, however, that only the procedural information should be provided in a just-in-time fashion.

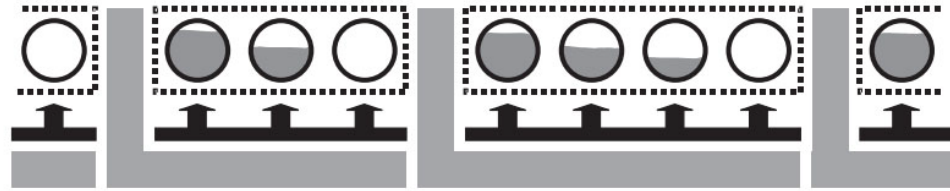


Figure 4: Just-in-time and Supportive Information Presentation. From EDUCATIONAL PSYCHOLOGIST, 38(1), 5–13, *Taking the Load Off a Learner's Mind: Instructional Design for Complex Learning* (p. 11), by J.J.G. van Merriënboer, P.A. Kirschner, & L. Kester, 2003, Mahwah, NJ: Lawrence Erlbaum Associates, Inc. Copyright 2003 by Lawrence Erlbaum Associates, Inc.–Reprinted with permission.

The black lines, with arrows pointing to each whole-task within a task class, represent the *procedural information*. Procedural information is provided in a just-in-time fashion and is intended to help the learner perform the consistent, recurrent aspects of the learning tasks. This information is typically simple and therefore can be provided to the learner during task completion without causing cognitive overload of the learner.

The gray L-shaped bar represents the supportive information for each task class. The *supportive information* consists of the non-recurrent information related to the mental model that is needed in order for learners to accomplish the whole-tasks within a particular task class. Supportive information is typically more complex and should be provided to the learner before the task instead of during task completion when additional cognitive load is undesirable. Though the supportive information should be presented to the learner before beginning the task, this information should also be available for the learner to refer back to during task completion.

In summary, procedural information should be offered just-in-time when the learner needs the information during task completion. Supportive information related to the mental model of the task class should be offered before the learner begins the tasks of

that task class, but also be available to the learner to refer back to at any time while working on the task.

Part-Task Practice

The first three components of the 4C/ID Model are consistent with the use of whole-task practice which is believed to support complex learning. However, when a learner needs to be able to perform a skill automatically without a significant increase to their cognitive load (such as the learning of multiplication facts), repetition that is difficult to provide in whole task activities is needed.

“In general, an overreliance on part-task practice is not helpful to complex learning. But if a very high level of automaticity is desired for particular recurrent aspects, the learning tasks may not provide enough practice to reach this level because the responsible learning process, strengthening, requires large amounts of not available repetition. For those aspects, additional part-task practice may be provided” (van Merriënboer et al., 2003, p. 11).

The portion of the schematic for *part-task practice* (Figure 5) incorporates the last component of 4C/ID — part-task practice.

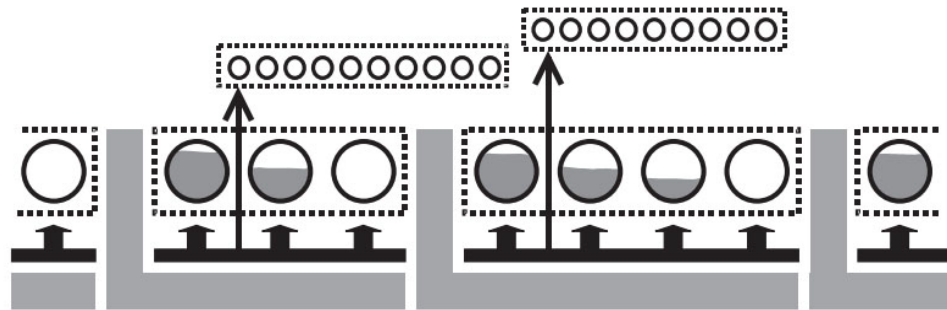


Figure 5: Part-Task Practice. From EDUCATIONAL PSYCHOLOGIST, 38(1), 5–13, *Taking the Load Off a Learner’s Mind: Instructional Design for Complex Learning* (p. 11), by J.J.G. van Merriënboer, P.A. Kirschner, & L. Kester, 2003, Mahwah, NJ: Lawrence Erlbaum Associates, Inc. Copyright 2003 by Lawrence Erlbaum Associates, Inc.—Reprinted with permission.

The schematic includes additional dotted rectangles which represent a task class associated with the skill that needs to be automated by the learner and circles which represent the partial tasks the learner will perform.

Overview of the Ten Steps to Complex Learning (TSCL)

The four components of the 4C/ID Model (Learning Tasks, Supportive Information, Procedural information, Part-task practice) provide a blueprint for designing instruction for complex learning (prescriptive) which informs what should be done to support learning *during* instruction. In contrast, the Ten Steps for Complex Learning (TSCL) provides an ID theory (also prescriptive) to inform the design of instruction *prior to* instruction. The four components of the 4C/ID Model and the ten steps of the TSCL are provided in Table 2.

Table 2:

Blueprint components of 4C/ID and the Ten Steps

Blueprint Components of 4C/ID	Ten Steps to Complex Learning
Learning Tasks	1. Design Learning Tasks
	2. Sequence Task Classes
	3. Set Performance Objectives
Supportive Information	4. Design Supportive Information
	5. Analyze Cognitive Strategies
	6. Analyze Mental Models
Procedural Information	7. Design Procedural Information
	8. Analyze Cognitive Rules
	9. Analyze Prerequisite Knowledge
Part-task Practice	10. Design Part-task Practice

Note. From *Ten Steps to Complex Learning: A systematic approach to four-component instructional design* (p. 10), by J.J.G. van Merriënboer & P.A. Kirschner, 2007, Mahwah, NJ: Lawrence Erlbaum Associates, Inc. Copyright 2007 by Lawrence Erlbaum Associates, Inc. Reprinted with permission.

You can see from Table 2 that the TSCL are derived from the 4C/ID Model and, so, are also consistent with Cognitive Load Theory (CLT). Note that the four components of the 4C/ID Model directly correspond with four design steps of the TSCL. “The remaining six steps [which are shaded] are auxiliary to these design steps and are only performed when necessary.” (van Merriënboer et al., 2003, p. 11). These steps provide more detail to the design step which they follow. Step 2 involves sequencing the task classes so that learning tasks begin simply and then gradually increase in difficulty. Step 3 involves setting the performance standards that must be met to complete each learning task. These performance standards are used to assess learners and provide them with appropriate feedback. Step 5 involves analyzing the cognitive strategies used by competent task performers in dealing with *unfamiliar* aspects of new tasks. Once these *problem-solving strategies* are identified, supportive information is designed to provide these cognitive strategies to all learners so they are able to deal with new tasks. Step 6 involves analyzing the mental models of competent task performers in order to provide supportive information to all learners. The mental model that is needed to achieve a particular learning task “...may take the form of a conceptual model (what is this?), a causal model (how does this work?), [or] a structural model (how is this built?)” (van Merriënboer et al., 2003, p. 131). Step 8 involves analyzing the cognitive rules that competent task performers use in solving *familiar* aspects of new tasks. Once these rules are identified, procedural information is designed to provide these rules to all learners so they are able to perform the procedure. Step 9 involves identifying the prerequisite knowledge needed *to be able to* perform the recurrent aspects of a complex task and providing this procedural information to all learners.

Though the TSCL is presented as a linear sequence for designing complex learning to provide a “workable – and understandable – model description that is needed for a systematic approach to the design process” (van Merriënboer et al., 2003, p. 28), the implementation of the model in real-life design projects is meant to be iterative and involves switching between steps as needed.

A Closer Look at the TSCL

The TSCL consist of ten steps intended to facilitate the effective design of instruction to support complex learning. In considering each step, it is important to realize that the steps are not intended to be followed sequentially, but instead used in a flexible and iterative manner. Each step is summarized below.

Step 1: Designing Learning Tasks

Step 1 involves identifying whole learning tasks and organizing them into appropriate task classes. The tasks within a task class should all rely on the same mental model and knowledge which is required to complete the tasks of that task class. Difficulty of tasks within a task class should increase for the learner because of fading instructional support, not because of increased complexity. The first task of each task class should be a worked-out example which demonstrates to the player how to effectively complete the task. The instructional support in each subsequent task of the task class should be faded gradually. The last task of the task class should be a traditional problem in that it requires the learner to complete the task with no instructional support (proving mastery). Also, variation should be provided in the learning tasks within each task class to promote transfer of learning to different situations.

Step 2: Sequencing Task Classes

Step 2 of the TSCL is closely related to Step 1. As learning tasks and task classes are designed, the task classes (not the tasks) should be sequenced progressively from simple-to-complex. The first task class should include learning tasks which require the player to apply only the most fundamental concepts to be learned. Subsequent task classes should include learning tasks which rely on the next most important concepts to be learned. In this manner, the last task class would introduce the least important concept to be learned but also provide the most complex tasks; those which require the application of the current concept and all prior concepts. By the time the learner completes the last task class, they have mastered all the intended knowledge, skills, and attitudes, and can apply what they have learned in an integrated manner.

Step 3: Setting Performance Objectives

Step 3 involves setting the performance objectives and performance criteria for each task class. Performance objectives are important in determining when a learner is ready to move on to a new task class. Performance criteria should be specified by the performance objectives so that mastery can be ensured. Mastery, therefore, is determined by the designer in terms of the degree of accuracy or efficiency with which learners must perform the task. Once a learner achieves the performance objectives, they are introduced to the next task class in the progression.

Step 4: Designing Supportive Information

Step 4 involves the design of supportive information related to the mental model that is needed to complete the tasks of a particular task class. Often, instructional

materials may already exist that can be used or modified for use. All supportive information should be organized to correspond to the particular task classes in which the information is needed.

Step 5: Analyzing Cognitive Strategies

Step 5 is helpful if instructional materials which support learning of supportive information need to be designed from scratch. This step involves identifying and analyzing the cognitive strategies that proficient task performers use to solve problems in the domain. Results of the analysis of cognitive strategies provide a basis for designing supportive information.

Step 6: Analyzing Mental Models

Step 6 is also helpful if instructional materials which support learning of supportive information need to be designed from scratch. This step involves identifying and analyzing the mental models that describe how the domain is organized. Results of the analysis of mental models provide a basis for designing supportive information.

Step 7: Designing Procedural Information

Step 7 involves the design of “how-to” information. Procedural information specifies how to perform the recurrent aspects of the learning task and should typically be provided at the moment it is needed by the learner. This just-in-time information delivery strategy reduces the cognitive load of the learner by not distracting him or her with the procedural information until the moment it is needed.

Step 8: Analyzing Cognitive Rules

Step 8 is helpful if instructional materials which support learning of procedural information need to be designed from scratch. This step involves identifying and analyzing the cognitive rules which specify the condition-action pairs that drive routine behaviors. Results of the analysis of cognitive rules provide a basis for designing procedural information.

Step 9: Analyzing Prerequisite Knowledge

Step 9 is also helpful if instructional materials which support learning of procedural information need to be designed from scratch. This step involves identifying and analyzing the prerequisite knowledge needed to correctly use the cognitive rules. Results of the analysis of mental models provide a basis for designing procedural information.

Step 10: Designing Part-task Practice

Step 10 is necessary when completing whole learning tasks does not provide enough practice for all constituent skills the learner needs to master. In some situations, additional practice is needed for aspects of a complex skill that the learner needs to be able to perform routinely. In this case, the learner may be taken out of the whole-task activity to be given part-task practice. Step ten involves designing any necessary part-task practice.

TSCL within an ISD Context

The TSCL is focused on analysis and design of instruction. According to van Merriënboer et al. (2003), the TSCL is best applied within an Instructional Systems Design (ISD) model. In addition to analysis and design of instruction addressed by the TSCL, most ISD models address development, implementation, and evaluation.

Engagement through Gameplay

Play is a fundamental activity of many species and was likely to exist in human behavior before games, formal learning, and even language. However, there are inconsistent definitions for play. For example, Vygotsky (1967) views play as a cognitive process of acting in an imagined scenario and that children play when they are unable to act in a desired way in the real-world. He states “play is such that the explanation for it must always be that it is the imaginary, illusory realization of unrealizable desires.” (p. 3).

In *Rules of Play*, Salen and Zimmerman (2004) claim that games are designed to provide *meaningful play*. They explain that “meaningful play in a game emerges from the relationship between player action and system outcome” (p. 32). This view represents games as systems and the play within game as system dynamics. Salen and Zimmerman go on to say that “meaningful play occurs when the relationships between actions and outcomes in a game are both discernible and integrated into the larger context of the game” (p. 32). For play to be considered meaningful play, the player must recognize the immediate outcome of an action and the actions effect on the game system as a whole.

Just as there are multiple perspectives on what constitutes play, there are multiple perspectives on how play relates to learning. Vygotsky (1967) discussed how play creates a zone of proximal development (ZPD) for learning to occur. His theory stated that a learner is able to learn up to a particular level without help. However, with help the learner is able to learn to achieve a higher level of learning. The difference between how much a learner is capable of achieving independently and how much they are capable of achieving with help creates a ZPD. Vygotsky (1967) believed that the fantasy and imagination which is a part of play creates a ZPD. Children are able to learn through play because play allows them to act in a way that is not possible in reality.

In *A Theory of Fun*, Raph Koster (2005) equates gameplay to the recognition of patterns. Koster's unique definition of gameplay leads to a common understanding of the relationship between play and learning. Koster recognizes that the level of engagement during play, and the continuation of play, is related to the difficulty level of play, or the difficulty of recognizing patterns. If a pattern is too easy to recognize or new patterns are not provided once the player recognizes the current patterns, the game becomes boring. If the patterns are too difficult to recognize, the player will give up. Play is most engaging when the patterns being shown are not too difficult to learn, but difficult enough to be challenging.

A definition of *gameplay* could be play which is confined within the rules of a particular game. Considering play from the view of Vygotsky, gameplay is different than play in that the “imagined” scenario is created completely or partially by the game designer — not the person playing. This is particularly true in digital games, where the designer creates all aspects of the environment from how objects interact to the detailed

textures used on objects and the landscape. Gameplay is different from play in that the player is exploring an imagined world, but not imagining the world themselves.

Instead of understanding gameplay from some perspective on the more general term play, it may be wise to define gameplay independently. A simple definition of gameplay is: *the actions taken by players in a game which are consistent with the rules of the game*. Actions taken that are not consistent with the rules would not constitute gameplay, but are a violation of gameplay; or cheating. Note the definition of gameplay provided here relies on an understanding of what a game is. Various definitions of game are provided below in Table 3.

The issue of providing the appropriate level of challenge to maintain high levels of engagement is particularly important in the development of games. When gameplay is too challenging, players feel frustration and anxiety and may give up. When gameplay is too easy, players may become bored and inattentive. At the appropriate level of difficulty, gameplay increases the likelihood of the player experiencing *flow*.

“[Flow is] a state of concentration so focused that it amounts to absolute absorption in an activity. Everyone experiences flow from time to time and will recognize its characteristics: people typically feel strong, alert, in effortless control, unselfconscious, and at the peak of their abilities. Both a sense of time and emotional problems seem to disappear, and there is an exhilarating feeling of transcendence” (Csíkszentmihályi, 1990, p. 1).

Games are famous for their ability to create a sense of flow in players. Becoming so engaged and engrossed in a game that time passes without notice and everything outside of the game seems to fade from the mind is a common experience of gamers. When educators and instructional designers consider the potential of games to promote learning, they undoubtedly reflect on how learners may reach that same state of flow.

Rieber (1996) reports that flow results from optimizing challenge, providing clear goals, and providing clear and consistent feedback related to progression towards goals — which are all characteristics of games. Rieber notes that the indications of individuals experiencing flow (attention is completely absorbed in the activity, other worries and frustrations are temporarily forgotten, feelings of self-consciousness disappear, time passes without notice) also characteristically result from gameplay.

“Optimizing challenge is particularly important in order to experience flow” (Rieber, 1996, p. 48). The challenging aspect of effectively applying the principle of appropriate difficulty is that all players begin with different ability levels and learn at different rates. Games need to adapt their difficulty level to players at the same rate of their skill mastery in the game, regardless of when that growth occurs. This is further complicated in open-world games in which each player has very different experiences depending on how they choose to traverse the world. For a game to be designed to maintain engagement of diverse players, the concept of customization (or customized learning) should be embraced.

Just as there is no consensus on the definition of play, there is no consensus on the definition of a game (Garris, Ahlers, & Driskell, 2002). Koster (2005, p. 13-14) offers various definitions of game from both practitioners and researchers (Table 3).

Table 3:

Definitions of GAME

“activity which is...voluntary...uncertain, unproductive, governed by rules, make believe”	Roger Cailloise – author of <i>Man, Play, and Games</i>
“a rule-based formal system with a variable and quantifiable outcome, where different outcomes are assigned different values, the player exerts effort in order to influence the outcome, the player feels attached to the outcome, and the consequences of the activity are optional and negotiable.”	Jesper Juul – game researcher and theorist
“a subset of entertainment limited to conflicts in which players work to foil each other’s goals.”	Chris Crawford – game designer and theorist
“a series of meaningful choices”	Sid Meier – designer of the classic <i>Civilization</i> computer games
“a system in which players engage in an artificial conflict, defined by rules, that results in a quantifiable outcome.”	Salen and Zimmerman – authors of <i>Rules of Play</i>
“exceptionally good patterns to eat up”	Raph Koster – author of <i>A Theory of Fun for Game Design</i>

Regardless of what the best definition is for a game, most people recognize a game when they see it. “Play appears to be one of those constructs that is obvious at the tacit level but extremely difficult to articulate in concrete terms—we all know it when we see it or experience it.” (Rieber, 1996). Instances when debate arises as to whether or not something is a game, evidence the inconsistency of how games are defined. In these instances, the product in question is most likely to have some but not all features that are typical of games. The more characteristics a product has that are consistent to what is believed to characterize a game, the more game-like it is (Garris et al., 2002).

Simulations, for instance, are very game-like if they include fantasy, a challenge/goal, and a way to win.

Most people also realize how engaging, or even addictive, “good” games can be. Some educators and educational researchers believe that the engagement of entertainment games can be replicated in educational games. For example, Dickey (2005) states that “game design provides assistance to instructional designers not in the form of a system or a formula to be applied, but rather as a type of architectural model for promoting engaged learning” (p. 80).

Garris et al. (2002) also view educational games as having the potential of maintaining high levels of player engagement. They believe this can be done through a cyclical process of user judgments, user behavior, and system feedback. Garris et al. (2002) provide an illustration (Figure 6) of “a tacit model of learning that is inherent in most studies of instructional games” (p. 445).

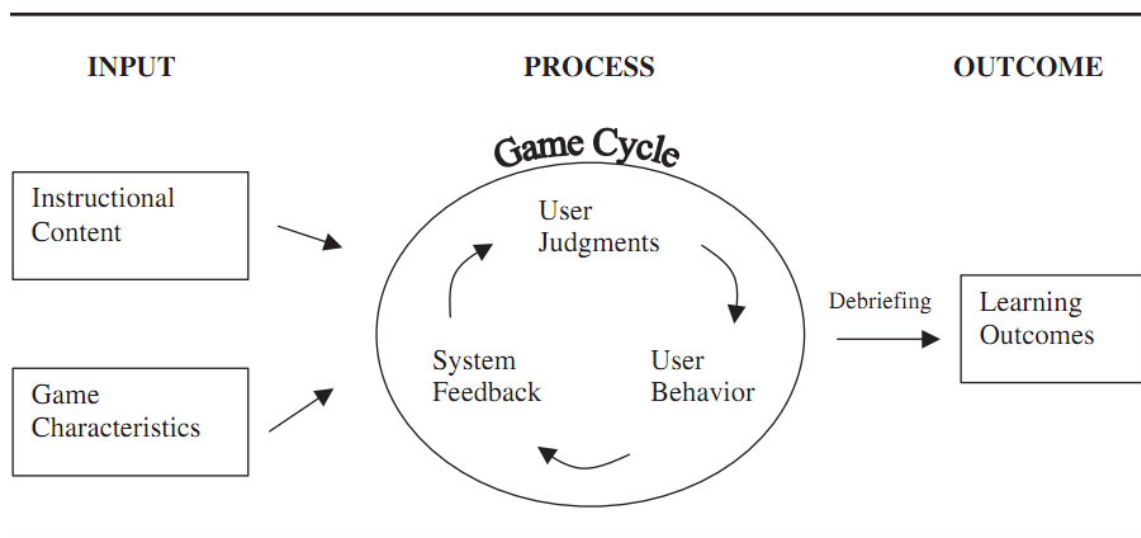


Figure 6: Input-Process-Output Game Model. From Games, motivation, and learning: A research and practice model (p. 445), by R. Garris, R. Ahlers, and J.E. Driskell, Simulation Gaming, 2002, 33 (4), 441-467. Reprinted with permission.

The first step of the model involves designing the game to include both instructional content and game characteristics. “These features trigger a cycle that includes user judgments or reactions such as enjoyment or interest, user behaviors such as greater persistence or time on task, and further system feedback. To the extent [the designer is] successful in pairing instructional content with appropriate game features, the cycle results in recurring and self-motivated game play” (Garris et al., 2002, p. 445). The model ends when the cycle ends and the learning outcomes are achieved. Garris et al. (2002) view the game cycle as the feature of computer gameplay that maintains player engagement over repetitive play and motivates them to play the game recurrently over time. This is the feature that researchers, educators, and training professionals who believe in the potential of games to promote learning hope to capture and incorporate in educational games (Garris et al., 2002).

Game-Based Learning

The *Magic Circle*, first describe by Johan Huizinga (1955), is the space which is intended to be bound in time and space outside of the real-world. This concept has been applied to games (Salen & Zimmerman, 2004). When players choose to play a game (join the Magic Circle) they are accepting to follow the rules of the game with the understanding that whatever happens during the game will not affect life outside of the game (outside of the Magic Circle). This is true of most *entertainment* games, though exceptions do exist such as with games of chance that involve gambling. Non-entertainment games, however, are intended to impact the player in the real-world so the construct of the Magic Circle is not as applicable. Depending on the purpose of the

game, players may earn a certification, take political action, become healthier, or transfer what they have learned to solve real-world problems or complete real-world tasks.

Various terms exist to describe games which are designed to promote learning of content and the transfer of what is learned to situations outside of the game itself — but none are sufficient in meaning and scope.

The term *serious game* was used at least as far back as 1970 in Clark Abt's book "Serious Games". However, the scope of this term is too broad because it includes games which have *any* purpose other than entertainment. "Serious games are games with purpose beyond just providing entertainment. Examples include, but are not limited to, games for learning, games for health, and games for policy and social change." (Serious Game Design, 2010).

Edutainment (formed by combining the words education and entertainment) is another popularized term related to games which have learning objectives. Resnick (2004) discusses concerns of combining education with entertainment.

"The problem is with the way that creators of today's edutainment products tend to think about learning and education. Too often, they view education as a bitter medicine that needs the sugar-coating of entertainment to become palatable. They provide entertainment as a reward if you are willing to suffer through a little education. Or they boast that you will have so much fun using their products that you won't even realize that you are learning – as if learning were the most unpleasant experience in the world." (p. 1).

Another term, *learning game*, could cause confusion as it could be interpreted in two very different ways. Learning games may describe games which are meant to promote learning or which learn themselves. In the latter case, learning games would include any game that becomes more "intelligent" over time by learning from its own

successes and failures. For example, the game 20 Questions (20Q.net, 2010), becomes better (smarter) the more the game is played by learning from answers provided by players in previous game sessions.

Game-based learning (GBL) is a term for the learning that results from playing games which have learning objectives. This term describes the learning (process) players undergo by playing a game, but not the game (product) itself. A *GBL game*, therefore, may be an appropriate term in scope and meaning for a game which has the primary purpose of promoting learning to situations outside of the game.

Educational game is a term that infers that the game will provide learning that is part of some formal curriculum. Though this may not always be the case for games that are designed to support learning, this may be the best term currently in the literature to discuss serious games which are designed to support learning. This paper uses the term *educational games* to refer to games in which the players are expected to meet desired learning objectives and apply what they have learned to real-world situations outside of the game. This paper uses the term *game-based learning* (GBL) to refer to the process of learning that occurs from playing an educational game.

Regardless of what terminology is used to discuss educational games and GBL, the question of whether or not games are effective in promoting learning should be addressed. In considering this question, a lesson can be learned from the media debates which are famous in the field of Media Studies. The debate was between those who agreed with Richard Clark (2005) that media will never influence learning and those who agreed with Robert Kozma (1994) that media does influence learning. The disagreement

was on whether particular media (e.g. blackboards, books, televisions, radios, and computers) are more appropriate for meeting particular learning objectives. Kozma (1994) proposes that instead of attempting to prove that media influences learning, researchers should focus on identifying “how” media influences learning and what actual and potential relationships there are between media and learning. The media debates will likely never be resolved as new forms of media are continually met with research agendas designed to assess the effectiveness of the media on learning. Researchers are encouraged to focus their research around new technology. For example, in the fall of 2010, the Faculty Learning Community (FLC) at Indiana University were encouraged to conduct research which utilized the iPad, a new and popular technology, by providing a free iPad and \$750 for professional development purposes such as travel to conferences.

One lesson from the media debate is that instruction can be well-designed or poorly-designed using any media. Therefore, studies which attempt to compare one instructional medium to another by comparing learning performance of participants is largely unhelpful. For example, a computer game designed to promote learners knowledge and ability in algebra may be more or less effective than a video tutorial, depending on the quality of the game and of the video. Comparing one medium to another is not helpful because of the great number of variations in how the instruction may be designed within the medium.

Another lesson from the media debate is that instructional methods to deliver content are a confounding variable which cannot be separated from the medium being used to deliver content. For example, a researcher may be inclined to test whether a video is more or less effective than a board game for teaching a particular concept by

using a two-group experimental design. One group would play the game as their intervention and the other group would watch the video, and learning gains for both groups would be measured. The video provides non-interactive direct instruction while the board game provides discovery learning and learner interaction. If a significant difference in learning gains between the groups were observed, the researcher would not know if the cause for the learning gains was the medium (board game vs. video) or the method (non-interactive direct instruction vs. interactive discovery learning). Furthermore, as mentioned previously, the researcher would not know how much the quality of the video and the quality of the game affected the findings.

A much better approach to the selection of appropriate media is based on more practical concerns related to cost of development and distribution as well as the ability of a medium — given its technical affordances — to support a desired instructional approach. More important than the question of, *Does media influence learning?*, are the questions: *What media will be most efficient for delivering instruction using the desired instructional methods?* and *How can instruction best be designed within the chosen medium?* For example, if cooperative learning is a desired instructional approach, then the instructional designer should consider how effective different media are in supporting cooperative learning and which of those media are most cost effective for developing the instruction.

These same lessons can help us answer the question of whether or not games should be used for learning. Just as with deciding whether a particular medium should be used for learning, the answer is – it depends. What it depends on is not whether or not other delivery methods are better or worse, but instead on what practical concerns there

are in providing the instruction and what features of games support the desired instructional approaches. Again, the question should not be *Can games impact learning?*, but instead *How can games impact learning?* and *Should a game be used for a particular learning task?*. Often digital games have a high cost of development but, once created, can be distributed consistently to a large number of learners. There is much variation in games and so they can be designed to support many instructional methods. Discovery learning and experiential learning are two instructional methods that games are particularly useful in facilitating.

Games are a form of simulation in that they allow the user to manipulate the environment they are in. As such, they have the same benefits that simulations have over real-world tasks. They provide a safe and controlled environment which allows for failure with little or no consequence. They provide learners with well-designed practice that can be repeated frequently. They save resources when a high number of repetitions are needed, when the instruction needs to be provided to a large number of people, or when resources needed in real-life training are too costly.

Games have features that may influence learning additional to those features which are shared with simulations. Garris, Ahlers, and Driskell (2002) note there is some debate over identifying the characteristics of games which promote learning. “Although many have noted the potential benefits that may be gained from incorporating game characteristics into instructional applications, there is clearly little consensus regarding how these essential characteristics are described” (p. 446). Based on a review of the literature, Garris et al. (2002) identified six broad dimensions for game characteristics: fantasy, rules/goals, sensory stimuli, challenge, mystery, and control. Table 4 provides

the description which Garris et al. provide for each game dimension. These game dimensions are believed to promote learning or increased engagement which leads to learning.

Table 4:

Game dimensions that promote player learning

Game Dimension	Description
Fantasy	Imaginary or fantasy context, themes, or characters
Rules/Goals	Clear rules, goals, and feedback on progress toward goals
Sensory Stimuli	Dramatic or novel visual and auditory stimuli
Challenge	Optimal level of difficulty and uncertain goal attainment
Mystery	Optimal level of informational complexity
Control	Active learner control

Other features of more modern games which promote player engagement discussed by Dickey (2005) include player positioning (point of view), narrative, and interaction.

Apparently, many believe that games have potential to promote learning indirectly by increasing learner engagement through the effective use of identified game features. However, games may promote learning more directly as well. James Gee (2007) provides 36 learning principles that are built into good video games. Gee claims that games which effectively employ these principles promote learning. Eight of the 36 principles are summarized below.

- Active, Critical Learning Principle – the learning environment promotes active and critical learning instead of passive learning.
- Amplification of Input Principle – learners are provided a great amount of output (feedback) for a relatively small amount of input.
- Practice Principle – Learners are provided much practice in an environment that is not boring which promotes their time on task.
- “Regime of Competence” Principle – Learners spend much of their gameplay time operating within, but at the outer edge of their abilities. This challenges the player without discouraging them from rising to meet the challenge.
- Probing Principle – Learning involves a cycle of probing the environment, reflecting, forming hypothesis, and re-probing to test the hypothesis, and then accepting or reformulating the hypothesis.
- Concentrated Sample Principle – Learners are provided many more instances of fundamental signs and actions early on so that they get to practice them often and learn them well.
- Discover Principle – Learners are provided as little overt, direct instruction as possible to allow them to experiment and make discoveries on their own.
- Distributed Principle – Meaning and knowledge is distributed across players and “smart” objects in the game.

Instructional Design of Educational Games

Some guidance exists for designing instruction for educational games. An and Bonk (2009) provide 12 key principles that are common to the simulations and game-

based learning literature. The principles, which form the acronym “SPECIAL PLACE”, are listed in Table 5.

Table 5:

Key principles for designing game-based learning environments

Scaffolding	Pause to reflect
Problem-driven activities	Learning through failure
Exploration	Adaptivity
Context	Character
Interaction	Engagement
Agency	
Learning through doing	

This framework allows the designer much more freedom than many ID models provide, which some may argue to be more useful in the design of games and other forms of *art* whose creation relies on creative ability and artistic expression. The principles are meant to guide the designer but are not to be followed in any particular sequence, for any set of time, or with any specified amount of rigor. A search of the literature found no studies which used this framework in the development of game-based learning. Given the non-specificity and flexibility of the framework, however, the application of the framework would vary greatly from one case to another. Like most ID theories in their early stages of development, further research should be done to improve the model and in this case, possibly give more specificity for (novice) instructional designers to follow.

Another ID theory that could be useful in the design of educational games is a model presented by Reigeluth and Schwartz (1989) intended for designing instruction in educational simulations. This model provides a more specific approach to designing instruction. Reigeluth and Schwartz propose three phases of the learning process which educational simulations should activate. They are: (1) acquisition of basic knowledge,

(2) application of knowledge to the full range of scenarios, and (3) assessment of what has been learned. Their model for designing educational simulations is comprised of heuristics intended to inform the designer in following a set of prescriptions. These prescriptions include:

- Selecting the appropriate complexity for the simulation so that it does not overload the learner.
- Introducing the scenario, the goals and objectives, and the directions and rules
- Selecting between expository and discovery approaches to acquisition
- Providing opportunity to apply acquired knowledge and skills in a variety of scenarios
- Assessing and debriefing the learner after the application phase
- Setting the appropriate amount of user control in relation to players level of expertise
- Designing instruction to support different types of content (procedural, process, or causal).

For each of these steps, suggestions are made that were supported by the literature in the field of Instructional Design. For cases in which high motivation is required for instruction, Reigeluth and Schwartz (1989) provide a brief discussion of how to apply the theory to simulation games. The additional prescriptions made for games include establishing rapport between the player and the computer, presenting rules of the game,

providing a non-zero based scoring system, creating a competitive situation, and providing player control over some aspects of the simulation.

The model presented by Reigeluth and Schwartz (1989) provides more guidance for an instructional designer than the model offered by An and Bonk (2009), but is focused more on simulations than games. Additionally, the prescriptions for games are brief and outdated. Much research has been done related to the design of games and the instructional design of educational games since the model was presented in 1989 including the work from Gee (2007) and Garris et al. (2002). This is particularly true for digital games, which were still in their infancy in 1989 and have since become much more complex, immersive, social, and engaging due to technical advances and to the maturation of digital games as an art form.

Watson (2007) describes prescriptive models for educational game design which attempt to merge game design with educational theory. Watson briefly describes three models proposed by Amory and Seagram (2003), a revised version of one of these models proposed by Amory (2007), and an experiential gaming model proposed by Kiili (2005). Watson provides reasons why “none of the models succeeds in synthesizing the varied concepts into a usable design model” (p. 17).

Watson (2007) offers an alternative model, called the GATE model, to support educational game design. GATE stands for Games for Activating Thematic Engagement. “The goal of this design theory is to utilize video games to engage students in a topic and encourage further exploration within that topic” (Watson, 2007, p. 19). The GATE model is comprised of three primary methods:

1. developing the context, problem space or world of experience
2. preparing learners to benefit from game and implement game as designed
3. providing feedback to the learner

Each of these methods is supported by more specific and detailed sub-methods which provide guidance to the designer. After completing a study which explored the application of the GATE model, Watson identified a need for a fourth method:

4. evaluate effectiveness of the game

The GATE model provides a structured instructional design model which can be used for educational game design. However, like other proposed models for educational game design, the GATE model has not been thoroughly tested and is in the initial stages of its development.

Given the lack of established ID theories, models, or frameworks available for supporting the design of educational games, designers may consider the appropriateness and usefulness of ID models with a more broad scope; particularly those that are well suited for the types of learning objectives the players of the game are expected to achieve. Some ID theories may be more suited for application to educational games in general and some may be more suited to educational games with particular types of learning goals.

Games can provide rich environments with many elements that have a complex relationship with each other. Therefore, games may be useful in promoting complex learning. For games that do have complex learning objectives, the *Ten Steps for Complex Learning* (TSCL) may be particularly appropriate and useful. Though the TSCL and its

underlying 4C/ID Model is much more established in the field of instructional design, its applicableness to educational game design has not been explored.

Research Questions

Few studies have been conducted which test the application of particular ID theories to the design of educational games. No studies have been conducted that the researcher is aware of which have applied Ten Steps to Complex Learning (TSCL) to the design of educational games.

This study will explore the application of the TSCL to the Instructional Design of educational games which have complex learning objectives in order to identify potential improvements that can be made. Given this purpose, the study will be guided by the following questions:

1. How could the TSCL have been more useful in re-designing the DSG to be effective and efficient to the players who participated in this study?
2. How could the TSCL have been more useful in re-designing the DSG to be appealing to the players who participated in this study?

Chapter 3: The Case

A case study approach was used to conduct this research by selecting a case in which the *Ten Steps to Complex Learning* (TSCL) could be applied in order to explore its effectiveness in its application to the design of games. The research methodology (Formative Research) and the methods for the study are described in Chapter 4. Chapter 3 is included to provide a description of the case—the Diffusion Simulation Game (DSG) and the design expertise of the designers. First, a brief history of the DSG and a description of the most recent version, the DSG 2.0, are provided. Next, the learning objectives of the game are identified, including a description of how the concepts learned may be applied in the game as well as what support is provided to the player to help them discover how to apply the concepts effectively. A judgment on the effectiveness of the game is then made, based on its current design and empirical evaluative research which has been done with the DSG. Due to the deficiencies of the current DSG, a vision of a re-designed DSG consistent with the 4C/ID Model is illustrated. A justification for the selection of the Ten Steps follows. Next, the designer's expertise, being a central element of the design of the DSG, is described. Lastly, the researcher/designer's view on the relationship between appeal, effectiveness, and efficiency on games is provided.

History of the Diffusion Simulation Game (DSG)

The DSG was first designed and developed in 1976 as a board game by Michael Molenda and six Instructional Systems Technology (IST) graduate students, led by Patricia Young and Dale Johnson (Enfield, Myers, Lara, & Frick, 2012). The board version of the DSG was used in IST graduate courses at Indiana University to facilitate

learning of the Diffusion of Innovations theory. Multiple board games were created so that all students in a class could play the game in groups of about four. Because the board version of the game was designed to be played by multiple players, the effectiveness of diffusion strategies was discussed between players. Debriefing materials were also created and used with the students after the gameplay occurred. Debriefing was used to reflect on the gameplay and the Diffusion of Innovations Theory, and to clear up any misconceptions students may have acquired from playing the game.

As the IST department began to offer courses online, a need to digitize the DSG for use by distance students arose. In 2002, Dr. Theodore Frick had a group of students develop an online version of the DSG using PHP scripts and text files to store game session data. The online version was designed to be played individually and debriefing materials were available to instructors, but still not integrated into the game itself. Despite the game only being available to individuals with an Indiana University login, the game grew quickly in popularity. As IST students graduated and moved away from Indiana University, sometimes taking positions in other academic institutions, the number of requests for access to the DSG increased.

Due to the growing demand, a free, public version was made available in 2006 for unlicensed use which did not require a university login. This version of the DSG provided no gameplay logs for user inspection, no unique login names, and no debriefing guide—but was otherwise identical. Over 10,000 gameplays of the free, public version occurred from Oct 7, 2006 to April 4, 2009 (Enfield et al., 2012). Since then, an additional 13,000 game plays have been recorded, as of May 1, 2012.

In 2010, the beta version of the most recent version of the DSG was released. This version, named DSG 2.0, was developed by a group of five students in the Instructional Systems Technology (IST) graduate program at Indiana University under the leadership of Theodore Frick (Lara, Myers, Frick, Aslan, & Michaelidou, 2010). The team re-developed the DSG using Adobe Flex, the Model-View-Controller (MVC) framework, and a MySQL database to store the gameplay data. Some of the advantages which resulted from the improvements to the DSG are:

1. Adaptability of the game to facilitate other contexts/scenarios
2. Data storage to support more rigorous research
3. Elimination of page refreshes to improve usability
4. Content organized into regions of the game window so that content is persistently viewable to the player

However, the improvements did not change the overall gameplay mechanics or change how the DSG attempted to promote learning of the Diffusion of Innovations. As with all digital versions of the DSG, the DSG 2.0 promoted learning largely through inductive trial-and-error reasoning. Though instructors who use the DSG may provide students with external supportive information or debriefing, these instructional strategies were not built-in features of the game.

Description of the DSG 2.0

A screenshot of the home page of the DSG 2.0 is shown in Figure 7. The information on this page immediately places the player in the role of a change agent with the goal of persuading all the staff members of a junior high school to adopt peer tutoring

as an instructional method. The player's goal in the game is directly correlated to the learning objectives of the game — the ability to use strategies consistent with the Diffusion of Innovations Theory to diffuse an innovation (peer tutoring) throughout a system (the school). For a DSG player to win, they must persuade 22 of the 24 staff members (all but the secretary and janitor) to adopt peer tutoring within a simulated two year academic calendar.

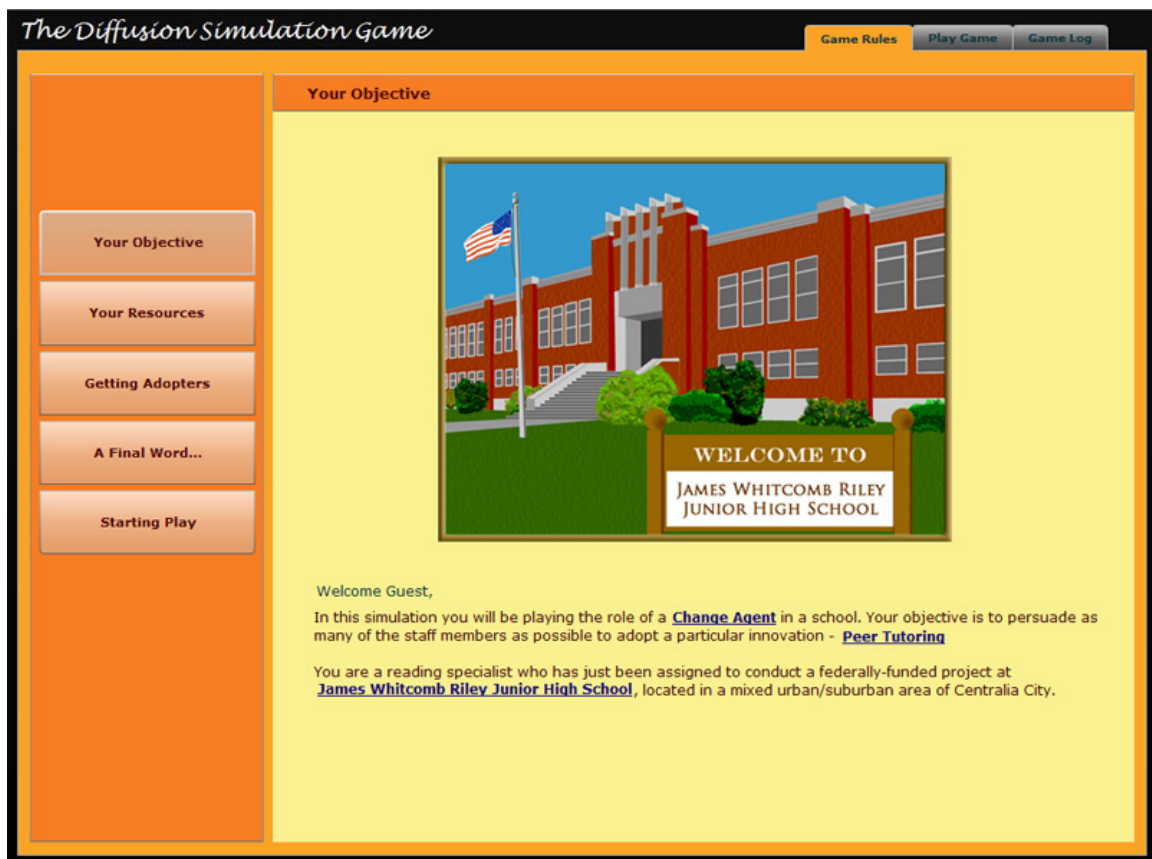


Figure 7. Home page of the DSG (version 2.0)

A screenshot of the DSG during gameplay is shown in Figure 8. Under the *Play Game* tab, the game screen can be divided into four major components — player progress, activities, staff members, and feedback.



Figure 8. Screenshot of the DSG 2.0 being played

The *Player Progress* component at the top of the game screen consists of the calendar and the text indicating the total number of adopters. This provides the player with information about how much time they have left in the game (the calendar) and how much progress they have made in persuading the staff to adopt the innovation (the number of adopters). The other three components provide the functionality for playing the game. The *Activities* component to the left of the screen consists of *Information Activities* and *Diffusion Activities*. The descriptions of these activities that are displayed when the user moves their mouse over an activity are provided in Table 6. The *Staff Members* component lists the faculty members in the school along with any information acquired about each staff member and an indication in the form of checkboxes of their

adoption state. The Feedback component provides the player with feedback for what activities and staff members are being selected as well as the result of using the activity with the selected staff members. Each turn the player takes consists of selecting an activity which has an associated cost in weeks, selecting one or more staff members for that activity, and then reading the feedback on how effective the use of the activity with the staff member selected was on moving staff members closer to adoption.

Table 6:

Description and cost of Information and Diffusion Activities

	Activity	Cost	Description
Information	Get Personal Info	1	Choose five staff members for whom you would like to obtain personal information.
	Lunchmates	1	Observe carefully who lunches with whom each noon.
	Committees	1	Find out who are members of the various formal committees set up in the school
	Social Network	1	Observe the out-of-school social patterns to learn who plays poker together, who bowls together, etc..
Diffusion Activities	Talk To	1	You make a conscious effort, over the period of about one week, to engage any ONE person in a number of one-to-one conversations
	Ask Help	1	You ask any ONE of the staff for advice or for help in one of your projects... preparing some learning materials, setting up a demonstration, running a workshop, etc.
	Pilot Test	2	You attempt to influence ONE teacher by asking to let you conduct an informal pilot test of peer tutoring with his/her students.
	Site Visit	4	You select any FIVE persons to visit Lighthouse School, in the next state, where an exemplary tutoring program is in progress.
	Print	1	You circulate a brochure describing the many advantages of peer tutoring to any FIVE persons.
	Presentation	3	You get on the agenda of a regularly scheduled staff meeting to explain about peer tutoring and encourage discussion about it.
	Demonstration	3	You invite the staff into a particular teacher's classroom (<i>an adopter's!</i>) to see peer tutoring in action.
	Workshop (Self)	5	You conduct an in-service workshop which trains teachers in the operational details of setting up and carrying on a peer tutoring program in their classrooms.
	Workshop (Prof.)	2	You arrange to have Professor Portney of Centralia Teachers college conduct an in-service workshop on "Peer Tutoring: Its Role in Student Self-Development."
	Workshop (Mats.)	5	You conduct an inservice workshop in which teachers team up to develop creative materials-games, flash-cards, etc. for student tutor use.
	Local Mass Media	1	You arrange to be interviewed about peer tutoring by a reporter from the local Eyewitness News program.
	Compulsion	6	You persuade the principal to issue a memo directing all teachers to institute some form of peer tutoring in their classrooms next year. (Use only if the principal has adopted the innovation.)
	Confrontation	6	You work behind the scenes with a group of parents, encouraging them to protest about the students' poor reading achievement. They take their protest to a school board meeting. (Use only if you have used mass media twice.)

The first information activity (*Get Personal Information*) is used to get information about descriptions of individual staff members. A requirement of the game is that the player must get personal information for a staff member before they are able to select them for any diffusion activities. Selecting any of the remaining three information activities (*Lunchmates*, *Committees*, *Social network*) reveals a diagram of the interpersonal communication channels that exist amongst the staff. For example, the *Lunchmates* diagram shown in Figure 9 provides a visual of which staff members eat lunch together.

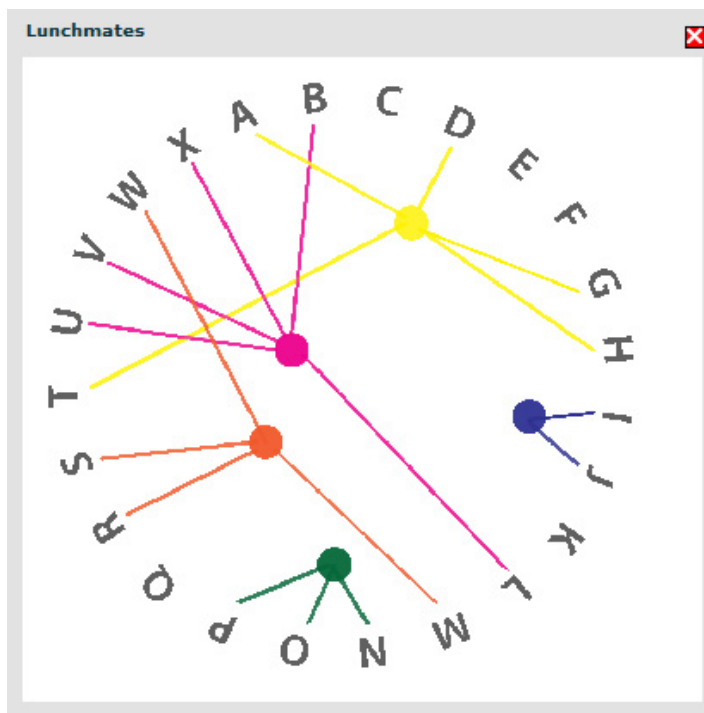


Figure 9. DSG 2.0 Lunchmates diagram

While information activities are important for the player to learn about the characteristics of staff members and their connectedness to other staff members, diffusion activities are the activities that the player, as the change agent, involves staff members in,

in order to persuade them to adopt the innovation. Each diffusion activity costs the player a different number of weeks to complete and has varying impact on the staff members selected depending on the staff members' characteristics, their current phase of adoption, and an element of chance. With only a two-year academic calendar to complete the diffusion process, selecting the most efficient diffusion activities with the appropriate staff members at the appropriate time in the game is crucial to winning the game.

Learning Objectives of the Diffusion Simulation Game

The DSG was designed to help players learn the concepts of the Diffusion of Innovations Theory and how to *apply* those concepts to effectively diffuse an innovation. “Diffusion is the process by which an innovation is communicated through certain channels over time among the members of a social system” (Rogers, 2003, p.11). Everett Rogers (2003) provides a thorough description of the Diffusion of Innovations Theory, which includes the work of many before him as well as his own significant contributions to the theory.

The core concepts of the Diffusion of Innovations theory were integrated into the gameplay of the DSG. They include: *Adoption Phases, Adopter Types, communication channels, opinion leaders, gatekeepers*, and the *role of the change agent*. Each of these core concepts of the Diffusion of Innovations theory as well as their integration into the DSG is described in detail by Enfield et al. (2012). The following is a similar description of the core concepts to be learned, how those concepts can be applied within the DSG, and the instructional support provided to facilitate learning. Additionally, mental models and learning objectives for each concept are introduced. These concepts are sequentially

ordered to introduce concepts which are most fundamental to the theory to those which are least fundamental to the theory.

Adoption Phases

Based on a large amount of prior research on the diffusion of innovations, Rogers (2003) identifies five phases of adoption which individuals pass through in their adoption of an innovation. In order, these are the knowledge phase, the persuasion phase, the decision phase, the implementation phase, and the confirmation phase.

“First, in the knowledge phase, the individual becomes aware of the innovation’s existence, learns how to use the innovation, and gains an understanding of how it functions. The individual then passes through the persuasion phase, weighing the desirable, direct and anticipated consequences with the undesirable, indirect and unanticipated consequences to form a favorable or unfavorable attitude towards the innovation. Next, in the decision phase, the individual chooses to adopt or reject the innovation. Often the individual first adopts the innovation on a trial basis before making the decision to fully adopt or reject the innovation. If the individual adopts the innovation in the decision phase, he or she enters the implementation phase by putting the innovation to use. The innovation may be implemented exactly as it had previously been used by earlier adopters or undergo re-invention — the modification of the innovation to some degree. Last, in the confirmation phase, the individual seeks reinforcement of the innovation-decision he or she has made” (Enfield et al., 2012).

The Adoption Phases of the DSG are a simplified version of the phases of adoption provided by Rogers. In the DSG, players must advance individuals (staff members) through the Adoption Phases of *awareness*, *interest*, and *trial*. A mental model for the Adoption Phases within the DSG is provided in Figure 10.



Figure 10. Mental model of the phases of adoption within the DSG

The mental model may be sufficient for representing the phases and sequence of phases which individuals go through when adopting an innovation, but they do not provide any information about *how* to move individuals through the innovation-decision process. Figure 11 provides a more complex mental model for representing the Adoption Phases within the DSG as well as a description of the types of activities that would most effectively progress individuals through the phases.

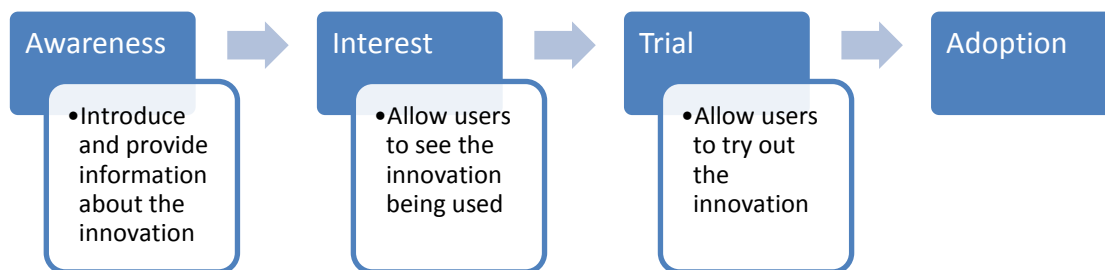


Figure 11. Mental model of the phases of adoption within the DSG and the types of activities most effective for moving individuals through the phases

In the DSG, each staff member has a variable number of boxes spread across the four Adoption Phases. The number of boxes that are filled-in indicate the current adoption phase of the staff member in the innovation-decision process as well as how far through their current phase they have progressed. The screenshot in Figure 8 illustrates how the boxes are used to indicate to the player where each staff member is in the innovation-decision process. The number of boxes, and the number of boxes which are filled-in, provide the player with feedback on their progress. Likewise, the number of boxes awarded for using a given activity with selected staff members provides feedback to the player as to how effective the activity is, given the staff members selected and their current Adoption Phase. Additional feedback on the effectiveness of the players’

selection of activity and staff members is provided through text in the feedback area of the screen, which also explains how the boxes were awarded.

Though the feedback messages and the feedback boxes explicitly state what happens from a given activity/staff member selection, it typically does not provide the reason why an activity was or was not successful or even if the points being awarded represent a successful or unsuccessful result. In the current version of the DSG, players are expected to learn these lessons through inductive, trial-and-error reasoning; unless they are provided additional instructional support outside of the game. They are expected to learn what constitutes an effective outcome based on how effective and ineffective previous outcomes were. They are also expected to develop their own mental model (such as the model presented in Figure 11) by *discovering* the relationship between the type of activity and staff members' current Adoption Phases.

Adopter Types

Adopter types are another key concept of the Diffusion of Innovations Theory. Rogers (2003) categorizes individuals into five distinct adopter types based on their *innovativeness* — willingness to adopt innovations relative to others in their same social system. The adopter types are listed in Table 7 from the most to least innovative, along with the portion of the population that each adopter type typically represents and a description of the defining characteristics of the individuals that make up each category.

Table 7:

Adopter Types

Adopter Type	Portion of population	Characteristics
Innovators	2.5%	Innovators tend to be venturesome and able to cope with a high degree of uncertainty when adopting something new. They often make rash decisions which lead to setbacks when new ideas prove unsuccessful.
Early Adopters	13.5%	While being innovative relative to their social network, early adopters proceed with more caution than innovators. Their discrete use of new ideas often leads to a higher rate of success. Early adopters are also generally very cosmopolite—they stay informed of what is happening outside of their social network through mass media communication channels.
Early Majority	34%	The early majority follow the early adopters with deliberate willingness. Although they typically interact frequently with their peers, they seldom hold positions of opinion leadership.
Late Majority	34%	The late majority is typically skeptical of innovations and often adopt due to peer pressure or as an economic necessity.
Laggards	16%	Laggards are the last to adopt an innovation. They are traditional in nature and avoid change. Laggards are typically suspicious of innovations and of change agents. They would be most likely to use the phrase: “if it’s not broken, don’t fix it”. Additionally, laggards often have little interaction with others.

Early Adopters generally possess the highest degree of opinion leadership due to their innovativeness, their high rate of success, and their awareness of what is going on outside of their social network. Laggards, in contrast, typically have very little or no opinion leadership due to their high level of skepticism and their lack of communication with others in the social network. Generally, Early Adopters make for good targets for

change agents who wish to speed up the diffusion process because of their openness to innovation and their ability to influence others in the system.

A mental model to support learning related to adopter types could look similar to Table 7. However, this table does not make explicit *how* to use the information to promote the diffusion of an innovation. The theoretical information is provided, but the procedural information needed for task performance is not. A more developed mental model, or a supplementary mental model, may be useful for understanding how to best use adopter types. Figure 12 provides a mental model for diffusing an innovation which could be used in the context of the DSG. The model relies on supplement the information about Adopter Types (Table 7) and about Adoption Phases (Figure 11).

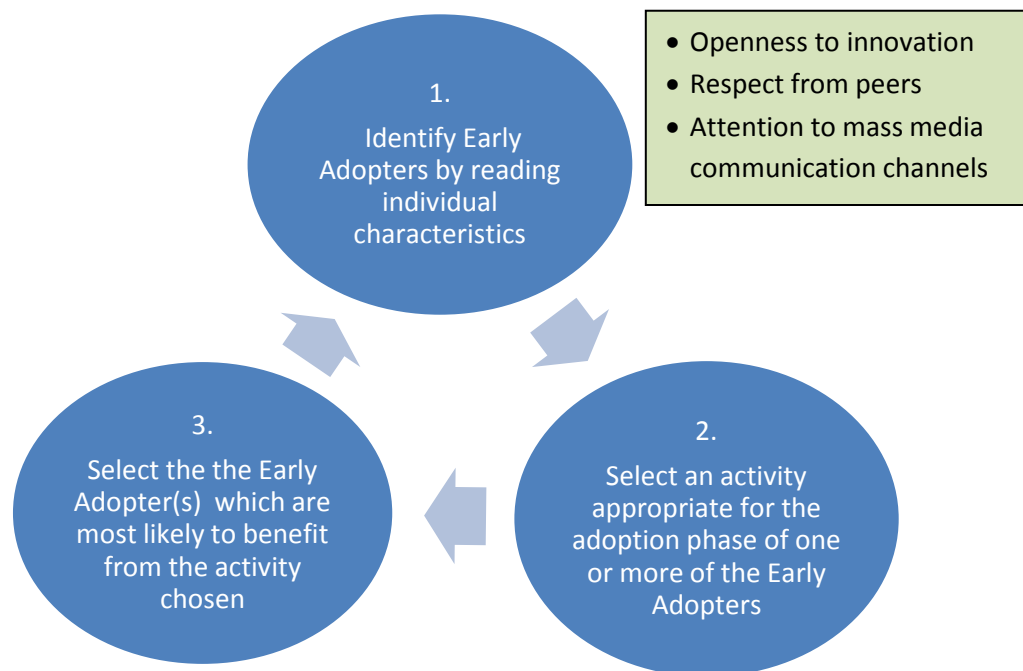


Figure 12. Mental model for promoting the diffusion of innovations by targeting influential individuals (Early Adopters) for activities that are appropriate for their adoption phase

The first step of this model involves using information about adopter types to identify Early Adopters. In the DSG, this can be done largely through analyzing staff members' descriptions. Characteristics of Early Adopters include an openness to innovation, respect from peers, high success rate in using innovations, and their attention to mass media communication channels.

The concept of communication channels — “the means by which messages get from one individual to another” (Rogers, 2003, p. 18) — is also relevant to the identification of Early Adopters. According to Rogers, Early Adopters are typically more cosmopolite and stay informed about what is going on outside of their social system through *mass media communication channels* — those channels which reach large audiences (such as radio or television). Therefore, the mental model for selecting appropriate diffusion activities could be expanded to incorporate the use of mass media communication channels to raise awareness of the Early Adopters of a social system

Interpersonal Communication Channels

A second communication channel category Rogers (2003) provides is *interpersonal communication channels* — those channels which involve direct exchange between two or more individuals. Using interpersonal communication channels effectively to facilitate the diffusion of an innovation involves the use of opinion leaders and of social networks.

Opinion Leaders are members of the social system who have influence on other members of the system. Opinion Leaders may or may not be Early Adopters, but do share some of the same characteristics — they typically pay attention to external forms of communication, are respected by their peers, and are relatively innovative. However,

Opinion Leaders are also generally well connected through social networks and have followers who they have much influence over. An individual's *connectedness* can largely be determined through their social networks.

Social networks within a social system can be used to identify highly connected individuals as well as to target individuals indirectly through their interpersonal communication channels. There are two types of social networks which Rogers distinguishes. Formal social networks are those networks which are formed through formal meetings and roles such as formal committees. Informal social networks are those networks which are formed on a more voluntary, informal basis such as lunchmates. Generally, influence through interpersonal communication channels is higher in informal social networks than in formal social networks (Rogers, 2003). This is because the members of an informal social network are usually part of the network by choice and typically have similar attitudes. This common ground, or *homophily*, increases the degree of influence between individuals.

Within the DSG, staff members can be identified as Opinion Leaders by analyzing their personal information as well as by viewing the social diagrams in order to see how connected to the rest of the staff they are. Once Opinion Leaders are identified, they can be used to indirectly target other individuals in their social networks who are not persuaded by direct communication with the change agent (such as Late Majority and Laggards). The mental models presented previously could be expanded to effectively utilize interpersonal channels to diffuse an innovation. For example, it may be appropriate to select an Opinion Leader who has already adopted the innovation to demonstrate an activity. Though this activity would not be appropriate for moving the

selected staff member(s) through the Adoption Phases, it would be appropriate for moving the *followers* of the selected staff member(s) through the phases.

Gatekeepers

Rogers (2003) discusses the concept of gatekeepers. Gatekeepers are people responsible for the flow or stoppage of innovations into the group.

Role of a Change Agent

Change agents purposefully influence the innovation-decisions of members of a social system in a direction deemed desirable by a change agency (Rogers, 2003). In order to be effective in facilitating the diffusion of an innovation, change agents need to integrate their understanding of Adoption Phases, Adopter Types, opinion leaders, gatekeepers, interpersonal and mass media communication channels, and social networks. Even without consideration for the usefulness of the innovation itself, the integration of these concepts to diffuse an innovation to various situations is a complex task. The DSG was designed to give learners a simulated experience in how these concepts can be applied in an integrated fashion.

Effectiveness of the DSG in Facilitating Learning

Various studies have been conducted to study the effectiveness of the DSG which raise concerns about the learning that results from playing the game, particularly if no external instructional support or debriefing is provided.

Enfield et al. (2012) analyzed gameplay data from 2,361 completed game sessions and compared strategies used in successful game sessions with those used in unsuccessful game sessions. The study was conducted to verify whether or not the strategies that were

effective in the game matched with the strategies based on the Diffusion of Innovations Theory that should be effective in the game. Of the seven strategies identified by the authors as being consistent with the Diffusion of Innovation theory in the context of the DSG, only three were used more in successful game sessions. They were:

- Take a client-oriented approach by avoiding *Confrontation* and *Compulsion*.
- Provide opportunities for staff to evaluate the innovation.
- Select mass media communication channels early in the game to raise awareness of the staff.

The remaining four strategies predicted to be effective by the theory were used less in successful game sessions. They were:

- Get to know the staff by reading *Personal Information*, using *Talk To*, and observing the interpersonal networks (via the network diagrams).
- Utilize opinion leaders by selecting them for diffusion activities.
- Utilize interpersonal channels by selecting the highest networked staff members for diffusion activities.
- Utilize Early Adopters by selecting them for diffusion activities.

The authors note that the findings may be misleading due to insufficient data, which was originally stored to maintain game status instead of for facilitating research. A follow-up study is currently being completed to recreate the data and address these limitations.

Two other studies investigated the learning that resulted from playing the game with minimal instructional support. Lara, Enfield, and Myers (2010) conducted a study which assessed the learning that resulted from playing the DSG three times. Additional supportive information — a three page summary of the Diffusion of Innovation theory —

was provided to the learners after their first game session. Kwon and Lara (2010) conducted a study which assessed the learning that resulted from playing the game one time. During the gameplay, instructional support was provided in the form of prompts which included information for the overall strategies that could be used. In both studies, qualitative methods were used and the number of participants was low. Though evidence of learning was found in both studies, no participants from either study reached a level of mastery. The improvements in game performance and in the pre- post- test of learning were inconsistent between participants and pragmatically insignificant.

Various reasons could explain why the DSG appears to be ineffective in meeting its intended learning objectives. First, the game was originally designed as a board game and included debriefing materials; it was never intended to be used in isolation. Second, the instructional support provided in the two studies which assessed learning with the online, digital version of the DSG used a minimal approach to provide instruction to learners who had no prior knowledge of the theory. According to Kirschner et al. (2006), the use of minimal guidance approaches to learning is not effective for novice learners. Third, the studies presented a low number of gameplays to the participants. This is somewhat contradictory to some of the primary reasons to use games for learning. Educational games typically allow players to learn through many attempts (fail forward) and are intended to engage the player to increase time-on-task. Experienced players of the DSG recognize that many gameplays are necessary before concepts can be discovered through the inductive, trial-and-error methods which the DSG supports. Lastly, the learning objectives of the DSG call for complex learning. The concepts of the Diffusion

of Innovations must be integrated and few scaffolds are provided in the DSG to support complex learning.

The concerns related to how effective the DSG is for learning may be addressed by providing learners with additional external support and debriefing. However, providing external supportive information or debriefing in a consistent manner can be difficult. Furthermore, providing any form of synchronous debriefing in online courses can be challenging, both because it requires some of the students to work at the same time and because it requires a facilitator to be available whenever the students meet. An alternate strategy for improving the DSG to better facilitate learning of the Diffusion of Innovations theory is to re-design the game to better facilitate learning through the gameplay; instead of relying on external support or debriefing.

Selection of an Appropriate ID Theory

The need to lessen the cognitive load of players and to support the complex learning objectives of the DSG provided the primary criteria for the selection of a game design model to guide the re-design of the DSG. However, a literature review revealed no educational game-design models which specifically supported complex learning. Therefore, the search for an appropriate design model for the re-design of the DSG moved to more general ID models that could be applied to simulations and games.

The Ten Steps to Complex Learning (TSCL) was selected to guide the re-design of the DSG for two reasons. First, the TSCL supports the nature of learning (complex learning) which DSG play is intended to promote. The DSG requires players to understand variables related to the Diffusion of Innovations theory (e.g. Adopter Types, Adoption Phases, opinion leaders, gatekeepers, social networks, communication

channels, etc.), recognize the relationships between these variables, and apply this information in an effective manner. The TSCL is the most comprehensive ID theory which is intended to facilitate complex learning. In addition, prior studies suggest that players of the DSG often experience a great amount of cognitive load (Kwon & Lara, 2010; Lara et al., 2010). The TSCL attempts to lessen the cognitive load of learners in order to promote complex learning.

Applying the TSCL to the re-design and development of the DSG was expected to improve the games effectiveness in meeting its learning objectives as well as to address **the purpose of the study** — to inform how the TSCL may be improved for its application to the design of educational games; and provide educational game designers with a design case that utilizes an ID theory in the design of an educational game.

Re-designing the DSG following the TSCL was intended to reduce the cognitive load of players and increase learning that occurs from playing the game. The Formative Research methodology used in the study (described in Chapter 4) resulted in suggested modifications to the TSCL. These suggestions could further improve the DSG and may be applicable to similar situations (such as the design of instruction for other games) to which the model could be applied.

Design Expertise

The TSCL provide steps for providing instruction using the four components of the 4C/ID Model. However, the design of the task classes, supportive information, and procedural information could vary greatly from designer to designer. This variability is the reason why it is difficult to compare one ID theory to another or one medium to another. Using any medium, or following any ID theory, could result in a wide range of

products. The quality of the product is determined not only by the guiding ID theory and the given content, but also, and largely, by design expertise.

In this case study, the author of the study is the lead designer and developer. His primary profession is education. His design experience has come from projects completed in computer science courses, in courses completed for his M.S. in Educational Technology, and in courses completed for a Ph.D. in Instructional Systems Technology. He has also worked on various design projects individually and in teams outside of any course; including entertainment games, serious games, websites, social networking applications, and course materials. Many of these projects were conducted outside of any professional context. However, the designer worked part time for two years as a developer and Instructional Designer for a company developing adventure games intended to improve the literacy skills of children. Besides design experience, the author gained design expertise through his studies in the programs mentioned above.

The re-design of the DSG will be strengthened through guidance from colleagues. As the chair of the dissertation committee for this study and the primary faculty member currently involved with the Diffusion Simulation Game, Theodore Frick offered guidance. Frick has had many years of instructional design experience in an academic setting and is familiar with the Ten Steps to Complex Learning. Other committee members who provided guidance and who have instructional design expertise include Jeroen van Merriënboer, Elizabeth Boling, Bill Watson, and Ray Haynes. As the primary contributor to the development of the 4C/ID Model and the TSCL, van Merriënboer provided a design expertise directly related to the ID theory that was used in the study. Professor Boling has had years of experience in design and in the study of design. Dr.

Watson's design experience relates directly to the design of serious games. Dr. Haynes expertise is in evaluation and performance improvement. All of the committee members provided guidance to the design of the study during the dissertation proposal defense, prior to the start of the study. Additional guidance was provided more regularly from Frick and his SimEd research group. This group was comprised of doctoral students in the Instructional Systems Technology program who have varying levels of design expertise and are interested in research related to learning via simulations and games.

The effective design of instructional materials provided in the game was also supported in this study by using an iterative design, development, and data collection process. The data collected from gameplay sessions informed the design of the instructional materials; including type of instruction needed and timing and frequency which should be provided. Subject matter experts (Frick and his research group) validated that the instruction was accurate.

The description of the collective design experience is needed in understanding the full context of this case. A more or less skilled designer or design team would most likely have varying degrees of success in re-designing the DSG to promote learning, even if the same ID theory was used. Both the specific game that is being designed and the specific design expertise involved in the design need to be considered when making judgments on the transferability of the findings from this study to other situations. Any findings from this study should be further validated through research using various games and with designers who have various degrees of design expertise.

Relationship between Appeal, Effectiveness, and Efficiency

The experiences of designers affect their belief about what aspects of design are more important than others, what aspects available time should be spent on, and what design decisions to make when design influences are conflicting. An example relevant to educational games is the relationships between the appeal of the game and the effectiveness and efficiency in which it meets its learning objectives. Effectiveness of educational games is equivalent to the probability of the gameplay resulting in players meeting the learning objectives. A game in which 50% of players meet the learning objectives could be considered 50% effective. Appeal of educational games relate to how engaging and enjoyable the game is for players. How much do they enjoy playing the game and do they want to continue playing? Efficiency relates to the amount of resources (particularly time) required by the gameplay for learners to meet the learning objectives of the game. Often, what makes a game more appealing is the same thing that helps players to learn more effectively and efficiently. However, this is not always the case. When conflicts arise the designer must make decisions as to which element is more important (or sometimes, which element is more easily implemented).

As the lead designer of the DSG in this study, my view of the relationship between these important elements in educational games is illustrated in Figure 13. Priority is illustrated in the diagram by the level of transparency in each region. My belief is that, for educational games, design decisions that increase effectiveness generally take higher priority than those that increase appeal; and design decisions that increase appeal generally take higher priority than those which increase efficiency. Of

course, design decisions that positively affect two or all three of these elements are of even higher priority.

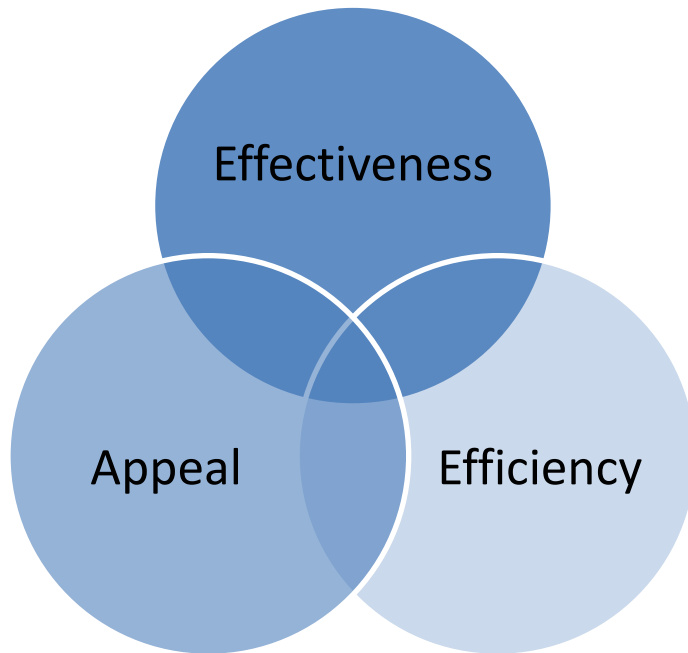


Figure 13. Relationship between effectiveness, appeal and efficiency

Effectiveness is held at the highest priority simply because the primary goal of an educational game is to help the players meet the learning objectives. Appeal is an important aspect for games in increasing motivation and should not be ignored, but is of less importance for educational games than the effectiveness of the game. If the game was appealing but not effective, it would cease to be an educational game and instead be an entertainment game.

Appeal is the next highest priority. Providing appropriate level of challenge and other game characteristics that increase player engagement is the reason that most instructional designers choose to use educational games in the first place. If the game is

not appealing, then why provide the instruction through a game? Fortunately for designers, much of what makes a game appealing also makes it more effective for learning, provided the gameplay aligns with the learning objectives.

The element with the least priority is efficiency. A strength of games is that they can be very engaging. Players are often willing to spend a great amount of time playing a game if they find it appealing (or fun). While efficiency is likely to be of higher concern for educators who teach in a traditional school that allows a limited amount of time to cover particular topics or sets of learning objectives, educational game designers are likely less concerned with this limitation (unless they are designing a game to be used in the traditional school context). The strength of well-designed games is that learners are often willing and want to spend a great deal of time playing the game. The lack of concern with efficiency in games in general is evidenced by the trial-and-error learning that most require. In fact, if a game does not last as long as a player expects it to, they may be disappointed and feel that they did not get their “money’s worth” for purchasing the game. For many players, figuring out how to play the game by failing forward (trying things and failing until they finally find a way to succeed) is what makes the game fun. Though allowing players to fail forward may not be the most efficient way of learning, it may be more appealing.

In the re-designed DSG, discussed in the next chapter, players will be provided with a large amount of instruction to support learning instead of relying on the trial-and-error learning that the original version of the DSG required. This design decision was made based on the prescription of the TSCL but also because of the designer’s view on the relationship between effectiveness, efficiency, and appeal. Though failing forward

(inductive trial-and-error learning) may be more appealing, it is likely to be less efficient as well as less effective than other instructional methods. As an analysis of 2,361 gameplay sessions of the original DSG by Enfield et al. (2012) revealed, players may have been learning the wrong thing through the inductive trial-and-error learning.

In summary, the researchers understanding of the relationship of the effectiveness, efficiency, and appeal of educational games stems from his design expertise. Based on his expertise, he believes that design decisions should be influenced primarily by their effect on the game's effectiveness, followed by their effect on the game's appeal, and lastly by their effect on the game's efficiency. This justification was used when making design decisions throughout the study. However, there were exceptions to this rule. Additionally, many other factors are influenced design decisions (see Table 17).

Chapter 4: Methods

Research Methodology

The research questions that resulted from the review of the literature, which were provided at the end of Chapter 2, are:

1. How could the TSCL have been more useful in re-designing the DSG to be effective and efficient to the players who participated in this study?
2. How could the TSCL have been more useful in re-designing the DSG to be appealing to the players who participated in this study?

These guiding questions are prescriptive in nature. They are concerned with “how to” improve a particular ID theory (the Ten Steps for Complex Learning built on the 4C/ID Model). Therefore, a developmental research method provided by Reigeluth and Frick (1999) called Formative Research was used. “The underlying logic of formative research as discussed by Reigeluth (1989) is that, if you create an accurate application of an ID theory (or model), then any weaknesses that are found in that application may reflect weaknesses in the theory, at least for some subset of the situations for which the theory was intended” (Reigeluth & Frick, 1999, p. 636). Formative Research’s “primary focus is on improving, rather than on proving” (Reigeluth & An, 2009).

Formative Research follows a case study approach (Reigeluth and An, 2009). According to Reigeluth and Frick (1999), the case may be a naturally occurring or a designed case which instantiates (as closely as possible) the ID theory that is to be improved. They go on to state that Formative Research can be used to create a new ID theory or improve an existing one. In this study, applying Formative Research

methodology was done to *improve* the TSCL by applying the TSCL to *re-design* the DSG. When *improving* an instructional-design theory through a *designed* case, Formative Research involves:

1. Selecting an ID theory to improve
2. Designing the initial “design case” to provide an instance of the theory
3. Collecting and analyzing formative data on the instance
4. Revising the instance
5. Repeat data collection and revision cycle
6. Offer tentative revisions for the theory

Step 1 was completed by selecting the *Ten Steps to Complex Learning* as the ID theory to improve in this study for reasons previously discussed. Justification for the selection of the TSCL was provided in Chapter 3 under the section titled “Selection of an Appropriate ID Theory”. Step 2 was achieved through the re-design of the Diffusion Simulation Game using the TSCL. The preliminary design of the new version of the DSG is provided in Appendix A. Note however that the TSCL is not meant to be done in isolation from the development of the game.

“...Real life design projects are never a straightforward progression from Step 1 to Step 10. New findings and decisions will often require the designer to reconsider previous steps, causing iterations in the design process. One may design a few learning tasks, in a process of **rapid prototyping,** before designing the complete educational program” (van Merriënboer et al., 2003, p. 11).

This cyclical design and development process of the TSCL is consistent with how games are typically created and with how Formative Research is conducted. Steps 3 through 5 involve *formative evaluation* to collect and analyze data to inform the re-design of the DSG. This study frames these steps in *Formative Research cycles* described later in this

chapter. Finally, step 6 was completed after the design and development of the DSG was completed and all the data had been analyzed.

Formative Research is a form of *Design Research* which Krippendorff (2007) describes as an oxymoron. Some of the contradictions between *design* and *research* noted by Krippendorff are summarized in Table 8. Design Research, according to Krippendorff, therefore should not be treated as traditional scientific research. “In fact, relying on re-search, being necessarily conservative, would condemn design to elaborations of the past” (Krippendorff, 2007). Formative Research is one approach to Design Research which is focused on the design, and/or the improvement of a design, for ID models.

Table 8:

Contradictions between Research and Design

	Design	(Scientific) Research
Prediction	Non-deterministic: Based on proposing novel and untested paths into alternative futures	Deterministic: based on past data and patterns
Causal explanations	Intent is that the designer affects the outcome through their own actions	Intent is that researcher does not affect observed phenomena
Abstraction	Designers suggest courses of action that will work for a particular situation in the future	Researchers offer generalizations through abstract theories or general laws
Variation	Concerned with conditions that could be changed by design.	Attempt to explain invariances
Acceptability	Concerned with plausibility and compellingness of design proposals	Concerned with truth (validity and reliability) of propositions established by observational evidence
Utility	Improve the world, at least in the dimension related to their own designs	Seek knowledge for its own sake, value-free, and without
Prediction	Non-deterministic: Based on proposing novel and untested paths into alternative futures.	Deterministic: based on past data and patterns

Participants

Twenty participants took part in this study, providing the data needed in order to collect and analyze formative data on the instance (Step 3). All participants met the criteria used to determine the eligibility for participation in the study. Participants were graduate or undergraduate students in a program that includes curriculum related to

change management and/or the diffusion of innovations. This is consistent with the target audience for the game. Also, participants had never played any version of the Diffusion Simulation Game and had no previous knowledge related to the Diffusion of Innovations theory.

Participants were recruited in phases, as needed. First, an email was sent to a representative of each department at Indiana University which was identified as having curriculum related to change management and/or diffusion of innovations, asking for permission to distribute an email to all graduate students in the department. The recruitment email which was sent to students is available in Appendix B. To encourage participation, volunteers were offered \$6 per hour as compensation for their time. When additional participants were needed, the same process was repeated at other universities which have departments providing instruction on the desired curriculum. Only departments from one university were approach at a time until there were enough participants to complete the study.

The need for usability testing as part of the formative evaluation provided a means for selecting the number of participants in the study. According to Turner, Lewis, and Nielsen (2006), most usability problems are detected with the first three to five subjects in a usability test and that using more than five participants is unlikely to reveal new information. Turner, et al. (2006) claimed that “Return on investment (ROI) in usability testing is maximized when testing with small groups using an iterative test-and-design methodology” (p. 1). Following these recommendations, I intended to have three to five participants for each of the Formative Research cycles of the study (described below) for a total of 15 to 25 participants. Often, however, fewer participants were

needed because critical usability and technical issues were quickly revealed, reducing the need for additional participants until the issues were resolved. The study involved 6 rounds of data collection with a total of 20 participants. Each round involved 2 to 4 participants who experienced a more developed version of the game than those participants in previous rounds.

Consistency with the First Component of the 4C/ID Model

This section describes the initial re-designed version of the DSG, how it is different from the current version, and how it is consistent with the first component of the 4C/ID Model.

The original DSG provides a single context (middle school), innovation (peer tutoring), and whole task (get middle school staff members to adopt peer tutoring). In addition, the staff members, staff member descriptions, activities, and social networks never change. Providing the learner with multiple whole tasks which represent a range of the various situations to which the diffusion of innovations may be applied is a key concept of the 4C/ID Model.

The first component of the 4C/ID Model relates to grouping whole learning tasks within task classes which require a particular mental model. Task classes are sequenced from simple to complex; and the tasks within each task class fade the instructional support from the first “worked-out” example (which provides a great deal of instruction) to the last “conventional” problem (which provides the learner with no instructional support).

The new version of the DSG implements this framework through the use of levels, a concept which is engrained in the tradition of digital games. As with all design decisions made in the creation of the game, the decision to use levels was recorded in a journal which will be discussed later in this chapter in the “Data Collection Instruments” under the subheading of “Design Journal”. Each level here represents a task class and provides the player with a corresponding mental model which is needed to perform the tasks within that task class. Just as the task classes of the game were presented to the players in the traditional game terminology of levels, the tasks that make up each task class were presented to players in the traditional game terminology of objectives.

- Task class (4C/ID terminology) = Level (game terminology)
- Task (4C/ID terminology) = Objective (game terminology)

The scaffolding mechanism for instructional support was provided, in part, through the use of a virtual mentor who provided direct instruction and guidance to the learner. The mentor’s guidance fades as the learner progresses through the tasks of the task class until the learner is able to perform the entire task with no support from the mentor. As the design matured throughout the study, additional game mechanics were added to provide additional instructional support such as sorting activities, information panels providing feedback on appropriateness and effectiveness of choices, and wrap-up activities to conclude each level. These game mechanics and learning activities are described in the design case (Chapters 5 through 11).

An outline of the initial design of the levels is provided in Appendix A, which includes the mental model, innovation, context for diffusing the innovation, and

objectives for each level. The initial design of the training levels (some of which were not developed due to the iterative nature of the design/development process) is described below.

Training Level 1

The first training level was designed to require a mental model of the Adoption Phases which a potential adopter would need to progress through in order to adopt the innovation. The learner would also learn how to identify which activities are most effective for persuading the individual given their current Adoption Phase. The whole tasks of this task class would have involved the player moving a single individual through the phases of adoption to persuade them to adopt the innovation. In this level, the innovation, the context, and the activities would have varied from one task to the next.

Training Level 2

The second training level would have required a slightly modified mental model of the Adoption Phases and appropriate types of diffusion activities needed to persuade six people on the board of a charter school to adopt a new admission process. This level would have forced the learner to distinguish between activities that target one individual and those that target two or more individuals. Because Level 2 would have required only a slight modification to the mental model developed in Level 1, the tasks in this level could have been combined with the tasks in the first level. However, this level was designed not only because of the slight adaptation to the mental model but also to introduce the increased complexity of the user interface which would require players to select one or more staff members for the selected activities.

The amount of variation in this level and following levels would have depended on the amount of time available for development. At the very least, variation in the innovation, context, and activities would have existed between task classes, if not between tasks within a class. A discussion about trade-offs due to resource limitations and conflicting design influences is discussed later in this chapter.

Training Level 3

The third training level would have required that the mental model developed in the first two levels be expanded to integrate the concept of adopter types. The whole tasks of this task class would have involved the player moving nine employees through the phases of adoption to persuade them to adopt a new office reward system. Players would have needed to learn to identify the early adopters of the system and use them appropriately to influence other members of the system.

Training Level 4

The fourth training level would have required that the mental model integrate the concepts of interpersonal communication channels, social networks, and opinion leaders. The whole tasks of this task class would have involved the player moving 11 rodeo clowns through the phases of adoption to persuade them to adopt the use of a new and improved safety vest. Players would have learned to identify the opinion leaders of the system and use them appropriately to influence other members of the system. Players would also have learned to target individuals indirectly through the interpersonal communication channels that exist through the social networks of the system.

Training Level 5

The fifth training level would have required that the mental model integrate the concepts of formal leaders and gatekeepers. The whole tasks of this task class would have involved the player moving 14 restaurant owners through the phases of adoption to persuade them to adopt a community rewards card. Players would have learned to identify the formal leaders and gatekeepers of the system and use them appropriately in diffusing the innovation.

Iterative Design and Development

Due to the iterative design and development process used in creating the new version of the DSG, the final product was quite different than the initial design described above. Most notably, the final product consisted of 9 objectives within 3 levels. A detailed description of the final product is described in Chapter 11: Round 6.

Consistency with the Remaining Components of the 4C/ID Model

This section further describes the *initial* re-design of the DSG, how it is different from the current version, and how it is consistent with the last three components of the 4C/ID Model; procedural information, supportive information, and part-task practice.

The original DSG provides no direct instruction about the Diffusion of Innovations. Instead of relying on instructional support, players must rely on system feedback and inductive, trial-and-error reasoning to discover ways to win the game which may or may not be consistent with the concepts that make up the Diffusion of Innovations theory. The information provided to the learner at the beginning of the game

also does not provide instruction for learning about the Diffusion of Innovations theory. This information is provided only to introduce the scenario (context and goals of the game) and how to play the game (game rules and user interface).

In the re-design of the DSG, consideration was given to how instructional information would be presented to the player based on the last three components of the 4C/ID Model – supportive information, just-in-time information, and part-task practice.

The *supportive information* is used for content that relates to the mental model of the task class. This information typically addresses the recurrent aspects of the task which the learner will need to use over and over again. According to the 4C/ID Model, this information should be presented to the learner at the beginning of the task class in which it is needed and be available for the learner to revisit at any time during the task performance.

The third component of the 4C/ID Model, procedural information, is used for content that relates to the procedural aspects for a particular task. This procedural information typically addresses the non-recurrent aspects of the task which the learner only needs to use in one particular instance or situation. According to the 4C/ID Model, this information should be presented just-in-time to the learner at the particular moment in the task performance in which the learner needs to apply the information.

The fourth component of the 4C/ID Model, part-task practice, is used for content that learners need to be able to use with a high degree of automaticity. When the practice provided in the whole tasks of a task class is not sufficient for learners to develop the

needed automaticity, the 4C/ID model prescribes that the learner be provided part-task practice until they are prepared to continue with the whole tasks in the task class.

The supportive information, procedural information, and the part-task practice was not been identified in the initial re-design of the DSG. These components were identified during the study as part of the formative design and development process (the implementation of the TSCL within an ISD process). However, the mental models presented in Chapter 3 provided an initial starting point in the design of some of the supportive information. There was no foreseeable procedural information that players needed to learn related to the Diffusion of Innovations theory in order to successfully complete the tasks. However, the gameplay itself (learning to play the game) involves procedural information. Specifically, players needed to learn that they must first select an activity, then select the appropriate number of staff members to involve in that activity, then continue with the activity, and then finally read the results and feedback of the activity. Note that because gameplay in most games must be learned and is often procedural, it was considered additional procedural information to the procedural information which directly related to the learning objectives. There were also no foreseeable skills which players would need to apply with a high level of automaticity which would require part-task practice. However, to be as consistent as possible with the 4C/ID Model's prescriptions, an attempt was made to categorize all emergent instructional materials appropriately. All design decisions were recorded in a journal and a distinction was made between those decisions that were consistent with the 4C/ID Model and those that were not.

Formative Research Cycles

Formative Research cycles were used to design and develop the tasks and task classes, collect and analyze data, and make revisions to the tasks and task classes. Table 9 provides the initial plan for the Formative Research cycles, which correlate to the five training levels (the five task classes designed to scaffold learning through simple-to-complex whole tasks). However, the Formative Research cycles were adapted during the study as needed. For instance, additional cycles were added to improve the first level before the development of Level 2 began. The initial plan for the Formative Research cycles were also modified in iterative rounds of the study as objectives and levels were added or removed from the design of the game. Using cycles of Formative Research to redesign the task classes of the DSG based on the data did not violate the TSCL, which is meant to guide design but not enforce a linear, sequential approach.

Table 9:

Tentative Formative Research cycles

Cycle	Develop/Revise	Collect and Analyze formative data
1	Develop task class 1	Task class 1
2	Revise task class 1 Develop task class 2	Task classes 1 through 2
3	Revise task class 1- 2 Develop task class 3	Task classes 1 through 3
4	Revise task class 1- 3 develop task class 4	Task classes 1 through 4
5	Revise task class 1- 4 Develop task class 5	Task classes 1 through 5

The Formative Research cycles also provided evaluative data on the quality of the supportive and procedural information provided in the DSG. Recall that Step 3 of the Formative Research methodology is to collect and analyze formative data on the instance. The question (and sub-questions) driving the collection and analysis of formative data on the use of the Ten Steps to Complex Learning (TSCL) with the DSG are:

1. How applicable were the TSCL to the design and development of the Diffusion Simulation Game?
 - a. Which steps, if any, of the TSCL were most useful for the design of the DSG?
 - b. Which steps, if any, of the TSCL were less useful for the design of the DSG?
 - c. What, if any, deficiencies of the DSG resulted from the use of the TSCL?
 - d. What, if any, design decisions were made to compensate for deficiencies of the DSG?

The methods used to answer these questions are described below. They include researcher observations of gameplay, participant feedback on their perception of the DSG and suggested improvements, and a pre- and post- test to measure learning that occurs from playing the DSG.

The iterative and progressive data-driven evaluation and development approach of the Formative Research cycles not only provided a means to collect data for research, but also provided opportunity to improve the type, quantity, and frequency of instruction. The importance of the quality of the instruction needed to be addressed in the study.

Poorly designed instruction would have likely result in a product that is less effective than what was possible. If the instruction within the DSG contained unclear information, was provided at the wrong time, or demanded too high of a cognitive leap for the user, the effectiveness would have been lessened. To provide higher quality scaffolding, modifications to the amount and quality of instructional elements during each Formative Research cycle were made.

Data Collection Instruments

For each Formative Research cycle, new participants were used and data was collected through various methods. Each participant initially completed a demographic survey and pre-test to identify participants' current ability to apply concepts from the Diffusion of Innovations theory despite having no knowledge of the theory. The participant then played the game one time from the first level through to the last level that had been developed. For the final Formative Research cycle, participants completed all levels, the last of which included the original DSG as its last objective. After the gameplay session, each participant completed a post-test in order to measure learning that resulted from the gameplay, followed by a semi-structured post-interview to identify improvements that could be made to the DSG. In addition to measuring the learning gains through performance improvement on the pre- and post-tests, gameplay and game performance were observed and recorded. All of these measures were used to assess participants' ability to apply the Diffusion of Innovations concepts. The data collection instruments are described in more detail below.

Demographic Survey

A survey (provided in Appendix C) was used to collect demographic information of the participants. Findings of a previous study conducted using the DSG (Kwon, Lara, & Enfield, 2010), revealed that learning outcomes may be influenced by participants first language, their experience in primary (k-12) schools in U.S., and their gameplay experience. This demographic information was collected along with participants' comfort level in working with computers and their prior *experience* related to the game content that was to be learned — experience in diffusing an innovation through a social system. This data revealed factors that influence player performance and attitudes and also helped explain some of the findings. For example, participants who were very experienced at playing games were more likely to try out strategies just to learn how the game would respond.

Pre-Test

A pre-test (provided in Appendix D) was given to assess participants' prior knowledge of the game-content that was to be learned. A previous study which assessed learning from playing the DSG (Lara et al., 2010) used a pre- and post-test with the same context of the DSG to frame fill-in-the-blank questions. A drawback of this method, in regards to the post-test, was that it was not possible to know whether participants answered based on their understanding of the theory or based on their previous game experience. A related drawback to this method was that transfer of learning was not tested because participants were only being asked questions to identify whether they had learned to apply the concepts of Diffusion of Innovations theory to the same scenario

which was provided in the game. In another study which assessed learning from playing the DSG (Kwon et al., 2010), a new scenario was created to frame the questions of the pre- and post-test. Though the scenario differed from the one presented within the game, the basic elements (description of activities, description of people in the system, diagram of the social networks, etc.) were similar. This allowed for assessment of transfer to a very similar situation, but did not provide the opportunity for learners to demonstrate far transfer to a much different situation. In both of these studies, the fill-in-the-blank test questions only allowed for a small set of possible responses and generally provided clues within the question which may have provided guidance to answering the question.

The pre-test (provided in Appendix D) for this study provided a very different scenario than all of the scenarios that were used in the three levels of the re-designed DSG. The pre-test scenario was taken from a case provided in Everett Rogers (2003) book titled *Diffusion of Innovations*. Using a scenario that is different from those provided in the DSG better supported assessment of learners' ability to transfer what they had learned to a new situation; a concept important for learning in general and for complex learning in particular. Additionally, the test consisted of one open-ended question which provided no guidance to how the question should be answered. The initial grading rubric (provided in Appendix E) was designed to score the open-ended response based on the learning objectives of the five levels that existed in the initial re-design of the DSG. As the game design changed over time, so did the grading rubric. The final grading rubric (provided in Appendix G) was used to score all participants pre- and post-tests. This rubric reflects the modified reduced learning objectives of the final three levels that existed in the final re-design of the DSG. The responses were scored

independently by the author and one other grader familiar with the Diffusion of Innovations theory to ensure reliability of the scores. The joint probability of agreement was 0.84 on the pre-test and 0.86 on the post-test. Afterwards, disagreements in scores were discussed by the graders until 100% agreement was reached.

Gameplay

Gameplay included a single game session. Screen capture software was used to record all game actions as well as audio from the game session for each participant. Other methods used to collect data during the game session varied between participants, becoming less intrusive in later cycles. In the earlier cycles, players were encouraged to think aloud and the researcher asked questions when clarification was needed and provided help when appropriate. In later cycles, the researcher only interrupted the player during the game session when necessary for the player to progress so that immersion/engagement with the instructional material was not disturbed. Instead the researcher made notes of questions along with the point in time of the recording in which the question arose. These questions were included in the interview following the post-test.

The gameplay data which was gathered from the final participants who played the entire re-designed DSG included data from the final objective of the game (the original DSG) and was used as an additional assessment of learning.

Post-Test

The post-test was given to all participants to assess their knowledge of the game-content that was to be learned in the levels which they completed. The post-test was the same instrument that was used for the pre-test (provided in Appendix D) and the same grading rubric was used (provided in Appendix G). For both the pre- and post- test, attention was given to the portion of the grading rubric which was designed to assess the learning objectives of the levels that were completed. For example, the first round of participants only played the first level of the game and so their score on that portion of the grading rubric related to the first level were most meaningful. Likewise, the entire grading rubric was more meaningful to the last round of participants who played through all levels of the game.

Semi-structured Post-interview

A semi-structured post-interview was used to identify ways in which participants believed that the game and the instructional-design within the game may be improved. The researcher/designer asked follow-up questions and analyzed the responses in order to discover what design issues existed, given the suggestions being offered. For example, when a participant suggested that the characters in the game should be animated, an attempt was made to discover why the participant felt the characters needed to be animated. In this way, the researcher/designer's design experience was used to provide an effective solution to the problem instead of relying on the design suggestions of participants who may have less experience in game design and instructional design. The questions which were asked as part of the first Formative Research cycle are in Appendix

F. The purpose of the interview was to collect data on player perceptions of the games usability, appeal, and effectiveness as well as their perception of the instructional support provided. For each of these, the participants were asked about what worked well, what did not work well, and what improvements they felt could be made. Additionally, questions the researcher had but did not ask during the later game cycles were included in the post-interview. In these instances, *stimulated-recall* techniques were used.

Design Journal

A journal was kept by the author throughout the entire study detailing all design decisions. This was used to distinguish design decisions made based on the author's design expertise, those made based on the prescription of the TSCL, and those influenced by both. For example, the decision to use levels in the redesign of the DSG was based both on prescriptions of the TSCL as well as the designer's expertise. The TSCL called for a set of task classes that were sequenced from simple to complex. The designer recognized that the levels (which are common in games) facilitate this requirement. The decision to use levels in the re-design of the DSG was therefore a combination of following the prescription of the TSCL and of the designer's use of an affordance of a prior solution.

Design expertise and the TSCL were not the only factors that influenced design decisions. Design expertise of others, consistency with the original DSG, consistency with previous levels, technical ability of the author, software affordances, findings from formative research and usability testing, knowledge of the content (Diffusion of Innovations), user feedback, and resource constraints (such as time and money) also

influenced design decisions throughout the design and development process and, therefore, the quality of the final product. The journal was used to document the reasons and justifications for the design decisions made.

Reflections of how to improve the DSG to support learning and how the TSCL may be adapted to facilitate the improvement of the DSG were recorded in the journal. These reflections were based on observations of gameplay and think-aloud data. Post-interview data was recorded for further analysis at the end of the study. In addition to recording design decisions, the journal was used to record all instances in which the author found the TSCL to be effective or ineffective; or efficient or inefficient; for designing the DSG.

The journal was also used to document trade-offs so that later reflections could be made on the impact of those trade-offs. Is a particular trade-off acceptable or detrimental to the application of the TSCL to educational game design? An example of a trade-off that had been considered in the initial re-design was to not provide variation between tasks in order to save development time. Though the Ten Steps calls for a variation between tasks with a task class, the initial design only offered variation between task classes. Because there was sufficient development time, this trade-off was not necessary and variation was added between tasks within each task class. However, if time had not permitted this added variation, this trade-off would have been made and later considered in regards to how it affected the game's effectiveness and efficiency of learning and its appeal.

The journal was also used to document trade-offs related to efficiency, effectiveness, and appeal. For instance, less user control in the worked-out examples may have lessened the appeal of the game while strengthening the effectiveness of the DSG in meeting its learning objectives. In this case, the prescription of the TSCL as well as the designer's belief that effectiveness should generally take priority over appeal in educational games resulted in taking away user control in the initial tasks of each task class. A description of the designer's view on the relationship between effectiveness, efficiency, and appeal was provided at the end of Chapter 3.

Data Analysis

A distinction should be made between data analysis that was used to improve the process (the Ten Steps to Complex Learning) and the analysis that was intended to improve the product (the DSG). Related to this distinction, further distinctions should be made in the analysis that was done to answer the question of *what* was the result of playing the game and of applying the TSCL (in terms of appeal, effectiveness, and efficiency of the DSG); the analysis that was done to answer the question of *why* the TSCL (the process) and the DSG (the product) were effective or ineffective; and the analysis that was done to answer the question of *how* the DSG and the TSCL could have been improved. A final distinction in the data analysis related to the improvement of the TSCL was between which improvements were specific to the design of the DSG and which may apply to design of other instructional resources. All of these distinctions should be kept in mind. However, they are not discussed separately below because the data collection and data analysis methods are not mutually exclusive within these distinctions.

The effectiveness of the DSG in helping players meet learning objectives was analyzed in various ways. Game actions, think-aloud data, and post-interview data were collected through screen capture software. This data were analyzed to identify evidence of learning, if any. This data addressed more than *what* is learned from playing the DSG. The qualitative data related to *how* to improve DSG, as well as the TSCL, were also recorded in the journal for reflection at the end of the study. The analysis of the data collected in the journal was used for the *Concluding Data Analysis* which is discussed in the next section. These formative data were then used to hypothesize about how the TSCL could have been adapted to better support this case (the DSG) and make predictions about what other cases may benefit from the same adaptations.

Game performance within each level over multiple attempts was also analyzed to provide an indication of learning. As a player's game performance on a particular level improved over multiple attempts, this indicated that the player was learning to make appropriate decisions in the game. Completion of the level (which involved completing the last task of the level with all scaffolds removed) provided further evidence of learning which indicated mastery of the skills needed to complete the level.

In addition to game performance within each training level, game performance on the final objective was used as an indicator of learning (for those participants who completed all levels). The task of the final objective was the same as that of the original DSG: convince as many of the 24 staff members of a middle school as possible to adopt peer tutoring. The final level provided no instructional support to players and was used as a summative assessment of participants' ability to diffuse an innovation. This assessment was calculated using two measures; total number of adopters and closeness-

to-adoption. Because two staff members (the secretary and janitor) could not become adopters, the maximum number of adopters for any game session was 22. The closeness-to-adoption measure was calculated by summing each staff members' individual closeness-to-adoption score — the ratio of their checked adoption boxes to their total number of adoption boxes. Because each of the 24 staff members had a closeness-to-adoption score of 0 to 1, the total closeness-to-adoption measure for the final level game performance fell in the range of 0 to 24. The minimum closeness-to-adoption measure of zero would indicate that all 24 staff members have a closeness-to-adoption score of zero. The maximum closeness-to-adoption measure of 24 would indicate that all 24 staff members have a closeness-to-adoption score of one.

Lastly, the change in players' response from the pre-test to post-test was an indicator of learning that resulted from playing the game. The pre-/post-test was designed to measure the learning of the DSG's intended learning objectives — application of the most fundamental concepts of the Diffusion of Innovations theory. Therefore, any performance improvement from the pre-test to post-test was a strong indicator of the DSG's effectiveness in helping learners' meet the desired learning objectives. Because the pre- and post- test was open ended, unexpected answers emerged. Reflections on what led participants to propose a plan for facilitating the diffusion of innovations were added to the journal. This information shed some light on what aspects of the DSG led to desired learning and what aspects led to undesired learning.

In addition to analyzing the *effectiveness* of the DSG in helping players meet the learning objectives and the reasons why the DSG is or is not effective, the *efficiency* of

the DSG was considered. To determine the efficiency of the DSG in helping learners' meet the desired learning objectives, the number of times a player repeated a level, as well as the total time spent on the level before passing it, was measured.

In addition to analyzing the DSG's effectiveness and efficiency for helping players meet the intended learning objectives, analysis was done on the appeal of the DSG to assess whether the game and each of the levels were entertaining and engaging. As discussed in the literature review, the engagement that results from appealing games is a primary reason that educators are interested in using games. Appeal is almost as important as effectiveness for games because the game needs to be appealing enough to maintain player engagement and increase the probability that the learner will continue to play. Regardless of how effective the game is, if learners quit playing because the game is not appealing, they will not learn. Post-interview questions were used to measure players' perception of the DSG and to identify appealing and unappealing aspects of the gameplay and of the supportive information. As noted previously, participants were given the opportunity to provide feedback during the post-interview on how the DSG could be made more engaging and how it could better support its learning objectives.

Concluding Data Analysis

Much of the analysis that was completed during the Formative Research cycles focused on improving the DSG's effectiveness, efficiency, and appeal. Formative data on how to improve the TSCL was also be collected during the Formative Research cycles but mostly analyzed after all of the Formative Research cycles were completed. Having completed the entire design and development of the DSG following the TSCL, the

concluding data analysis was guided largely by an analysis of the journal entries but also from the original data collected through gameplay observations and interviews. The data was categorized into emergent themes by the principal investigator. Evidence from the data which supported the emergent themes, exceptions to the recognized patterns, and interesting data which were not represented by the patterns were then organized to best answer the research questions. This method of analysis was used to answer the research questions of the study and inform the final step of the Formative Research process — suggesting tentative revisions to the TSCL.

Criteria for Judging the TSCL and Suggesting Improvements

Formative Research is emergent in nature as much of the data is collected from answers to open-ended *why* questions to “gain insights into the causal dynamics that underlie the effects of different methods in different situations” (Reigeluth & An, 2009). The emergent nature of this study was further emphasized because much of the data was collected from observations and reflections of design decisions made within a creative undertaking. Due to the emergent nature of the study, criteria for suggesting improvements to the TSCL were general. In re-designing the DSG, three criteria were used in judging whether improvements to the TSCL in its application to educational game design should be made; *sufficiency*, *expendability*, and *adaptability*.

The criterion of sufficiency (Are the methods enough?) helped to determine whether the methods offered by the TSCL were sufficient for the design of educational games or insufficient — requiring additional methods. This criterion addressed the concern of whether there is anything lacking in the TSCL that would be essential in

designing an effective, efficient, and appealing educational game. Therefore, sufficiency relates to the effectiveness of the TSCL; does the theory have what is needed to be effective in designing educational games? To judge the sufficiency of the TSCL, the methods which were needed in the re-design of the DSG, but not prescribed by the TSCL, were documented.

The criterion of expendability (Are the methods too much?) helped to determine which methods offered by the TSCL were expendable for the design of educational games. This criterion addresses the concern of whether there are any superfluous methods in the TSCL that could be eliminated. Therefore, expendability is focused on the efficiency of the TSCL; does the theory prescribe methods that are unnecessary and inefficient for designing educational games? To judge the expendability of the TSCL, the methods prescribed by the TSCL which were disregarded in re-designing the DSG were recorded. In fact, due to time and budget constraints, consideration was given to methods that may be unnecessary in order to meet the deadlines set to complete the study. The concept of trade-offs, disregarding particular methods to meet practical concerns, was discussed earlier in this chapter.

Lastly, the criterion of adaptability (Can the methods be modified as needed?) helped determine which methods were adaptable for application to the design of educational games. This is especially important in this study because the TSCL, which were originally provided to support curriculum design, were applied to educational game design. For example, the method of providing procedural information related to the learning objectives in a just-in-time fashion was adapted to include information related to how to play the game.

The journal, discussed earlier in this chapter, was used to record instances in which the methods provided by the TSCL were sufficient, expendable, or adaptable. Consideration was given to methods not prescribed by the TSCL found to be essential in the re-design of the DSG to determine if the need was unique to this case or relevant to other educational games. Likewise, consideration was given to methods prescribed by the TSCL which were not needed in this case study, to determine whether the method is expendable in only this case or in the design of other educational games. Lastly, consideration was given to methods which were modified (adapted) to support the re-design of the DSG, to determine the need for adapting the method in other educational game designs.

Chapter 5: Design Case Round 1

Overview of the Design Case

This Design Case (Chapters 5 through 10) gives a detailed description of the six Formative Research cycles, or rounds, which informed the iterative design and development of the game. For each round, the development of new levels and objectives are discussed. Likewise, the modifications to levels and objectives which were added in previous rounds are discussed. Also, the findings resulting from participants' completion of the demographic survey, pre-test, gameplay, post-test, and interview are provided. Further findings of each round are discussed within the description of the additions and modifications made to the game in the subsequent round.

Chapter 10 includes a description of the 6th and last round of Formative Research. Whereas Chapters 5 through 9 provides descriptions of only the additions and modifications made to the re-designed DSG in each round, Chapter 10 provides a comprehensive description of the entire re-designed DSG. After this summative description of the game is provided, Round 6 findings are discussed. Chapter 10 concludes with instructions on how the re-designed game may be played.

As part of the Formative Research methodology, reflections on the applicability of the TSCL to the re-design of the DSG were made after each round. These reflections are provided in Appendix K. Summative reflections are provided in Chapter 12.

Chapters 5 through 10 describe the design case at a high degree of detail. The design case is intended to serve as precedent for other designers who might apply the Ten Steps to Complex Learning (TSCL), or some other Instructional Design theory, to the

design of an educational game. The design case describes the game at every stage of development, illustrates the most significant design decisions throughout the study, and provides the reasoning and justification for each design decision. A concise description of the final version of the re-designed DSG is provided in Chapter 10.

The initial plan for the re-design of the DSG was described in Chapter 4 and is outlined in Appendix A. This initial design was created following the prescription of the TSCL which guided several fundamental design decisions. For example, instruction was embedded throughout the DSG to scaffold learning in the manner prescribed by the TSCL. While the original DSG described in Chapter 3 consisted of a single, whole, complex task (convincing 24 faculty members of a junior high school to adopt the peer tutoring teaching strategy), the re-designed DSG described below consisted of several whole tasks which increase from simple to complex.

The design case involved six rounds of design, development, data collection, data analysis, and reflection (Formative Research cycles). In each round, improvements were made to the objectives and levels that were created in previous rounds and newly designed objectives and levels were developed. Because changes were made in each round of Formative Research to all the objectives of the re-designed game, the version of the DSG that was created during each round must be considered when discussing any level or objective of the game. Therefore, the headings of the sections within Chapters 5 through 10 are labeled with the round, level, and objective relevant to the version of the game which is being discussed.

Round 1

The portion of the re-designed DSG which was developed in Round 1 consisted of three objectives which made up the first level of the game. These objectives are described in the next three sections (1.1.1, 1.1.2, and 1.1.3).

1.1 (*Round 1, Level 1*)

The first level of the re-designed DSG was intended to promote learning of the most fundamental concept of the Diffusion of Innovations theory – Adoption Phases. Specifically, players were expected to apply the concept within the three learning tasks (or objectives) of the level in order to persuade individuals to adopt an innovation.

1.1.1 (*Round 1, Level 1, Objective 1*)

1.1.1.A

The start screen (Figure 14) initially consisted of a white “mentor window” which overlaid the game screen. The mentor window was completely blank except for an image of the mentor and several buttons of which only the “Messages” button was enabled. The only action possible on the initial screen was to click the “Messages” button.

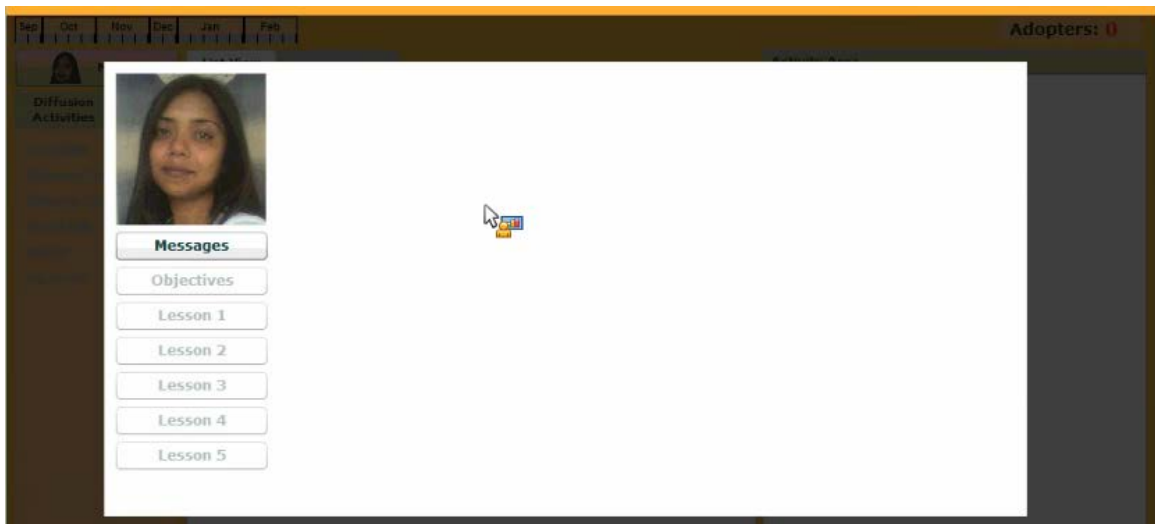


Figure 14. Screenshot of Round 1, Level 1, Objective 1; Mentor Window start screen

1.1.1.B

The “Messages” section of the Mentor Window provided the player with a brief welcome message from the mentor (Figure 15). Once the “Messages” button was clicked, the “Objectives” button became enabled so that the player could progress to the next screen.

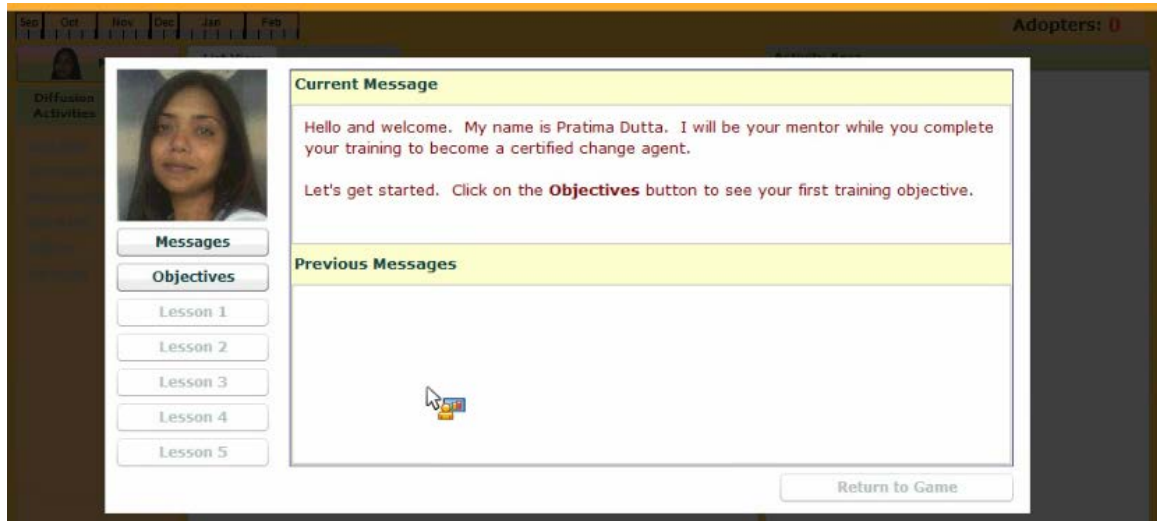


Figure 15. Screenshot of Round 1, Level 1, Objective 1; Mentor Window initial message

The space for “Previous Messages” was initially blank because no previous messages had been given. When the player returned to this screen at any time during the game, they could review all the messages the mentor had given during the current objective.

1.1.1.C

The “Objectives” section of Mentor Window (Figure 16) provided the player with a brief description of the first objective: “Get David to Adopt the use of Cornell Notes.” The space for “Completed Objectives” is initially blank because the player has not yet completed any objectives. Once the “Objectives” button is clicked, the “Lesson 1” button is enabled so that the player may progress to the next screen.

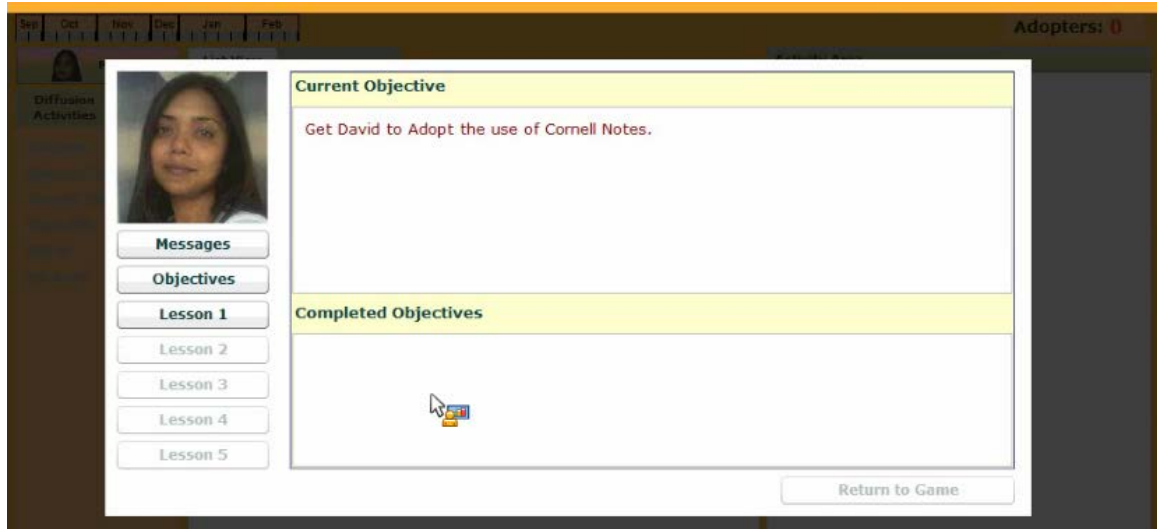


Figure 16. Screenshot of Round 1, Level 1, Objective 1; Mentor Window objectives

1.1.1.D

The “Lesson 1” section of the Mentor Window provided the player with an instructional video (Figure 17) which assigned them the role of a change agent in the game whose responsibility was to convince individuals in a social system to adopt an innovation.



Figure 17. Screenshot of Round 1, Level 1, Objective 1; Mentor Window Lesson 1 (18'' mark)

1.1.1.E

The instructional videos were designed to give players the supportive information they needed to complete the objectives in the each level of the game. Therefore, the Lesson 1 video was designed to support the player in completing the Level 1 objectives by providing information related to the Innovations-Decision process. To enable players to be successful in the Level 1 objectives, the phases of adoption (Awareness, Interest, and Trial) were discussed, as well as the types of activities most appropriate for each Adoption Phase. For example, at the three minute mark of the video the player was told that an individual must first progress through the Awareness Phase and that the best way to move an individual through the Awareness Phase is to provide them with information about the innovation (Figure 18). The player was subsequently told that the best way to move an individual through the Interest Phase is to provide opportunities in which they may see the innovation in use, and the best way to move an individual through the Trial Phase is to provide them with opportunities to try out the innovation on a trial basis.

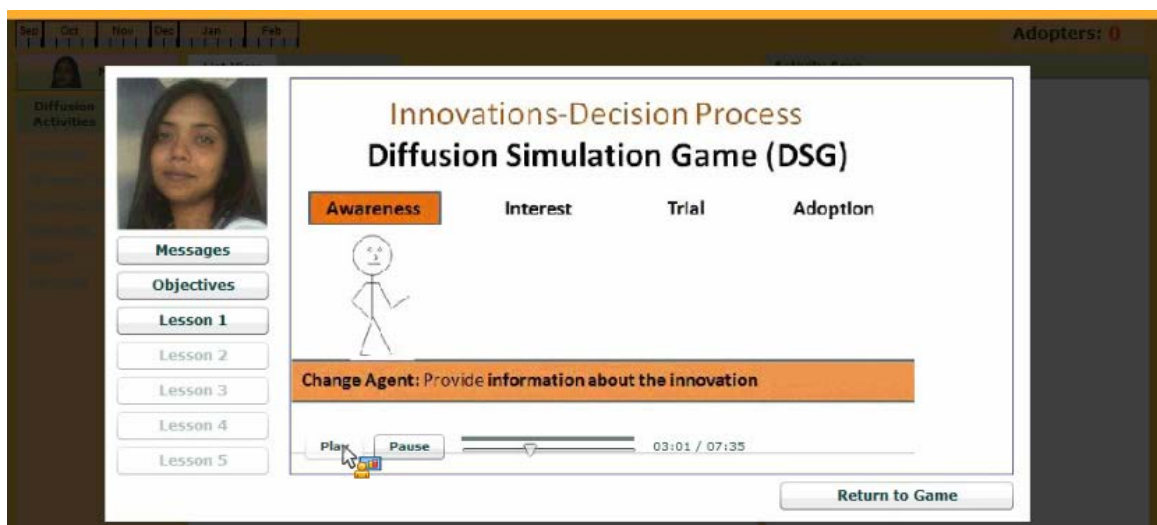


Figure 18. Screenshot of Round 1, Level 1, Objective 1; Mentor Window Lesson 1 (3' mark)

1.1.1.F

The video ended at the 3' 47'' mark with a call to action, telling the player it is now time for them to apply what they have learned in the video to complete the first objective of the game. Note that the total time on the video in Figure 19 shows 7' 35''. This was due to a bug which existed in the first round of the study which caused the video to be repeated. Players quickly understood the bug and skipped over the repetitive second part of the video and the bug was fixed prior to the second round of the study.



Figure 19. Screenshot of Round 1, Level 1, Objective 1; Mentor Window Lesson 1 (03' 47'' mark)

Once the “Play” button of the Lesson 1 video was clicked, the “Return to Game” button became enabled so that the player could close the Mentor Window and begin playing the game. The Mentor Window disappeared when the player clicked the “Return to Game” button.

1.1.1.G

Whereas the Mentor Window was used to provide the player with the supportive information which they needed to complete the tasks of the first level (as prescribed by the TSCL), mini-messages were used to provide the player with procedural information

in a just-in-time fashion. The mini-message in Figure 20, for example, tells the player that they may click on the “Mentor” button at any time to review the messages, lessons, and objectives. Providing the supportive information needed to complete the task prior to the player starting the task, allowing the player to access the supportive information at any time during the task, and providing procedural information in a just-in-time fashion are all prescriptions of the TSCL intended to reduce the cognitive load of learners.

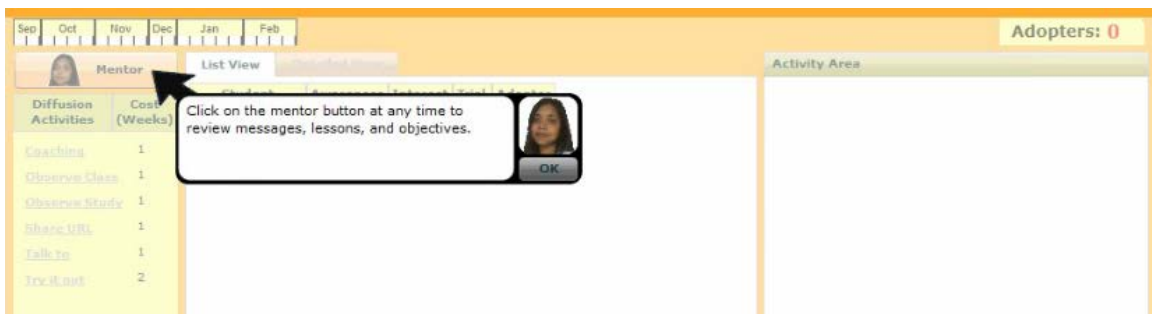


Figure 20. Screenshot of Round 1, Level 1, Objective 1; Mentor button mini-message

Notice that just as the Mentor Window appears over the top of the game screen, disabling the game by covering it with a partially transparent black layer (Figure 19), the mini-messages appear over the top of the game screen, disabling the game by covering it with a partially transparent white layer (Figure 20). This strategy was employed to force the player to attend to the Mentor Window and mini-messages before continuing their gameplay.

1.1.1.H

Immediately after the player presses the “OK” button of the first mini-message, a second mini-message (Figure 21) appears to introduce the player to the area of the game which displays the individuals in the system (David in this case) and their current phase of adoption (the Awareness Phase in this case).



Figure 21. Screenshot of Round 1, Level 1, Objective 1; Current phase of adoption mini-message

1.1.1.I

Immediately after the player presses the “OK” button of the second mini-message, a third mini-message (Figure 22) appears to introduce the player to the area of the game that lists the diffusion activities which the player may use to persuade David to adopt the innovation.



Figure 22. Screenshot of Round 1, Level 1, Objective 1; Diffusion activities mini-message

1.1.1.J

Immediately after the player presses the “OK” button of the third mini-message, a fourth mini-message appears which informs the player which diffusion activities are appropriate for individual’s current phase of adoption (Figure 23). Unlike the previous mini-messages which were intended to help the player learn how to play the game, this mini-message helps the player learn to effectively apply the concepts related to the Diffusion of Innovations that they were previously introduced to through the instructional

video (1.1.1.E). In this case, the information being provided is instructional support related to the learning objectives. Consistent with the TSCL, the first objective of the level provided the player with the most instructional support while subsequent objectives in the level gradually reduced the instructional support until the player was able to complete the final objective of the level with no support.



Figure 23. Screenshot of Round 1, Level 1, Objective 1; Activities appropriate for Awareness Phase mini-message

1.1.1.K

After the player presses “OK” on the first four mini-messages, they are allowed to begin playing the game. However, as the first objective was designed according to the TSCL to be the worked-out example of Level 1, the player was forced to make only appropriate activity selections. This was done by enabling only those activities which are appropriate for David’s current phase of adoption. Consider the example illustrated in Figure 24. Because David is in the Awareness Phase, the “Share URL” and “Talk to” activities are the only activities enabled because they are the only activities which provide information about the innovation.



Figure 24. Screenshot of Round 1, Level 1, Objective 1; Game screen

1.1.1.L

Consistent with the original DSG described in Chapter 3, an activity description was displayed as they moused-over each diffusion activity link (Figure 25).



Figure 25. Screenshot of Round 1, Level 1, Objective 1; Activity description

1.1.1.M

Upon selection of a diffusion activity, mini-messages were again used to continue introducing the player to the various elements of the game interface and the procedural how-to information needed to play the game. The mini-message in Figure 26 introduces the player to the Activity Area where directions for using the activity are displayed.



Figure 26. Screenshot of Round 1, Level 1, Objective 1; Activity Area mini-message

1.1.1.N

After the player clicks on the name of the individual they wish to include in the selected activity, the image of the selected individual appears in the Activity Area along with a “Continue” button. In Figure 27, the player clicked on “Share URL” to select the activity and then on David to select the individual to target for the activity. At this point, the player could change their mind by selecting a different activity, or follow through with their decision by clicking on the “Continue” button.

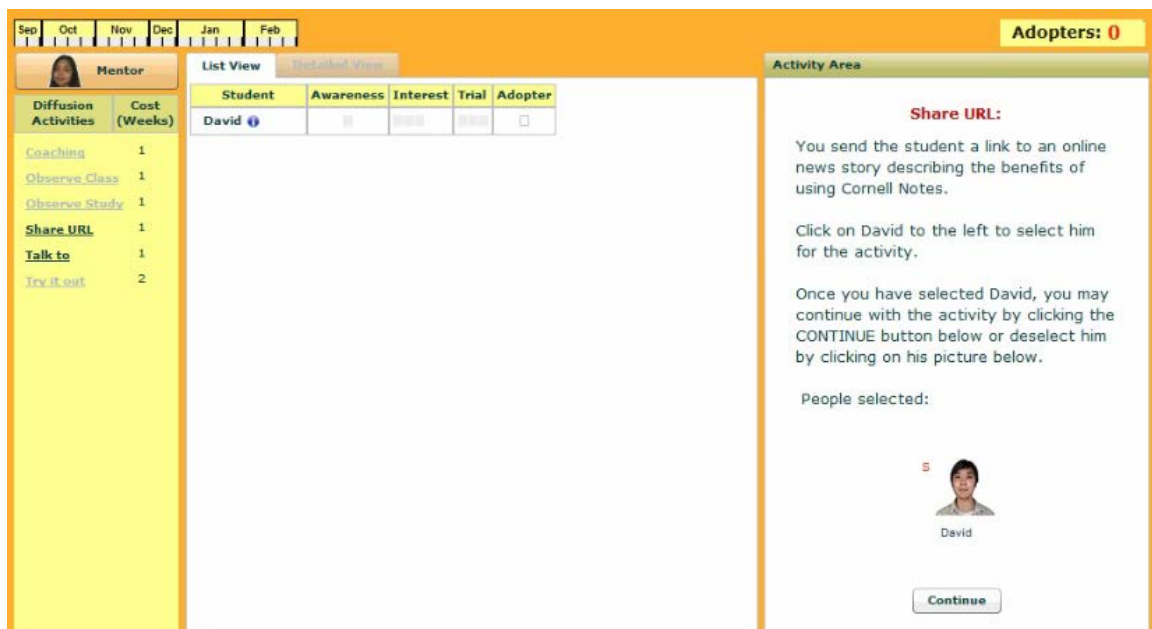


Figure 27. Screenshot of Round 1, Level 1, Objective 1; Continue with activity

1.1.1.O

After the player presses the “Continue” button to use an activity with the selected individuals, the outcome of their action is displayed in the Activity Area. The game has an element of chance so the outcome may or may not be effective. This is consistent with the original DSG. However, because the player is being forced in the first objective to use only appropriate activities for David’s current phase of adoption, the chances of the activity being effective are greater than if the player was using inappropriate activities.

If the outcome is positive then the player is awarded adoption points which are visually represented by green squares. The first time the player earns adoption points a mini-message appears to explain this relationship (Figure 28).



Figure 28. Screenshot of Round 1, Level 1, Objective 1; Adoption points mini-message

1.1.1.P

A mini-message is also provided the first time a player uses any activity to introduce the player to the game calendar (Figure 29), regardless of whether or not the activity is effective. This message is used to show the player that each activity has a cost in weeks and that they have a limited time to complete their objective.

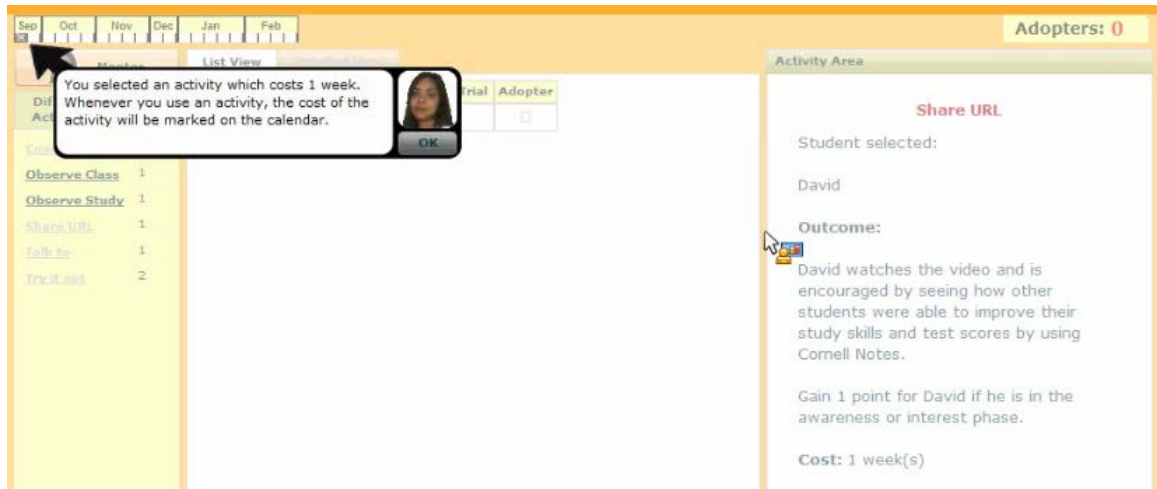


Figure 29. Screenshot of Round 1, Level 1, Objective 1; Game calendar mini-message

1.1.1.1.Q

Also after the player's first turn, mini-messages are provided to alert the player to two alternative methods for viewing personal information about the individuals. The first of these mini-messages alerts the player to the blue icon next to David's name which they may hover over to view information about David (Figure 30).

The personal information provided when the player mouses over the blue icon next to David's name states: "B average student. On the basketball team and is popular with his classmates. Somewhat disorganized with class assignments and notes but is open to suggestions."

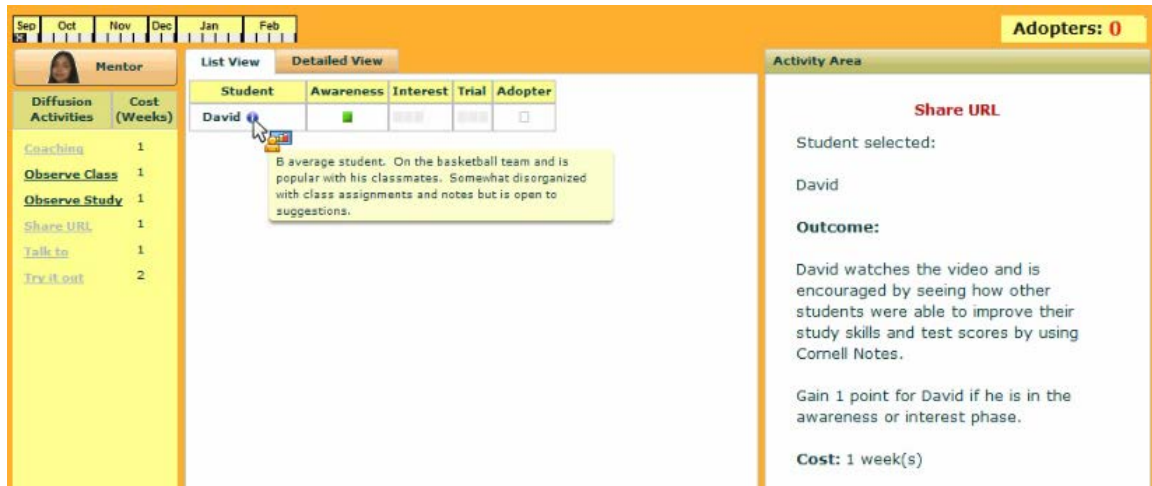


Figure 30. Screenshot of Round 1, Level 1, Objective 1; Information icon

The second of these mini-messages alerts the player to the “Detailed View” tab (Figure 31) which they may use to view David’s personal information in a persistent manner (without having to mouse-over the blue icon).

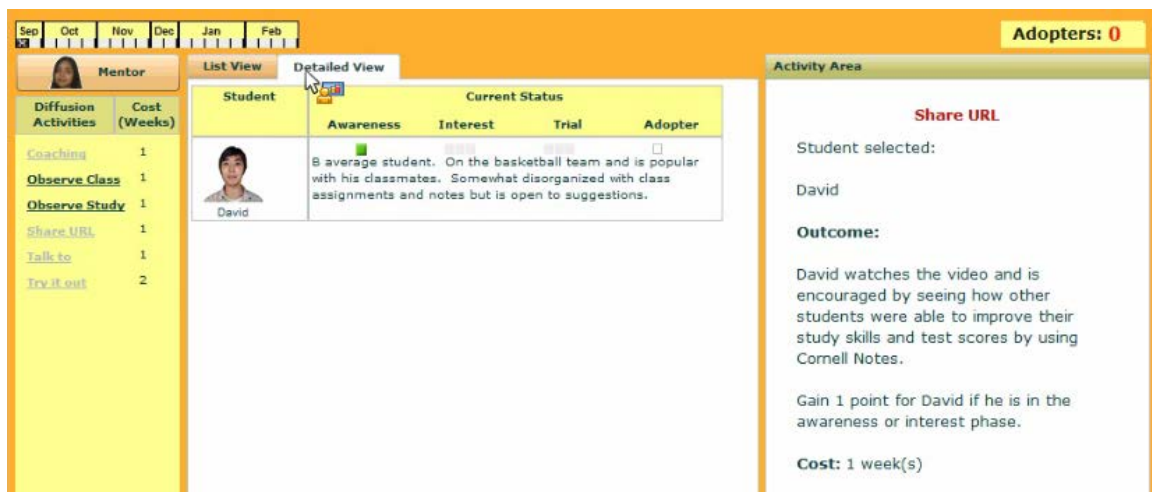


Figure 31. Screenshot of Round 1, Level 1, Objective 1; Detailed View tab

1.1.1.1.R

Once the player has earned enough adoption points to fill all the squares in David’s Awareness Phase, a mini-message (Figure 32) appears to inform them which activities are appropriate for the next phase of adoption — the Interest Phase.

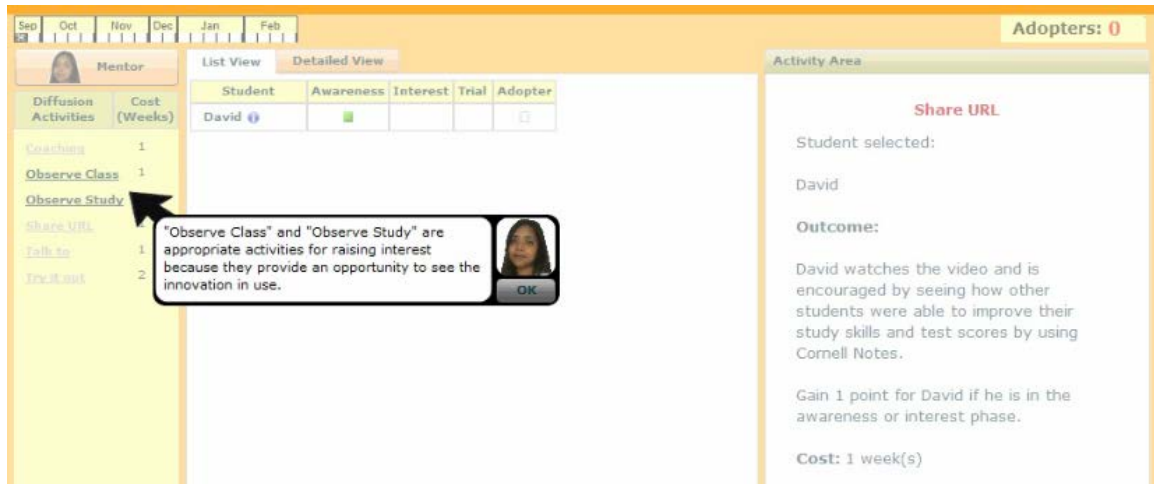


Figure 32. Screenshot of Round 1, Level 1, Objective 1; Activities appropriate for Interest Phase mini-message

1.1.1.1.S

As mentioned previously in 1.1.1.O, the outcomes resulting from activity choices have an element of randomness. Generally, an activity which is appropriate for the current phase of adoption of the person selected for the activity will be effective, and an activity which is not appropriate for the current phase of adoption will not be effective. However, due to the stochastic nature of the game, appropriate activities will sometimes not be effective and inappropriate activities will sometimes be effective.

Research from prior studies related to the original DSG revealed that the stochastic nature of the game often led to misconceptions. If an activity did not work, players were likely to think the activity would usually be ineffective. To address this foreseeable issue, a mini-message (Figure 33) was provided to the player after the first time they used an appropriate activity (as required in the first objective) without an effective outcome. The mini-message described this phenomenon and encouraged the player to “not let this deter you. Continue to use appropriate activities.” Additionally, the algorithm for randomly selecting outcomes was tweaked so that if the player had not

had a negative outcome by the time they reached the Trial Phase, their first attempt to use an activity in the Trial Phase would result in a negative outcome. By doing this, each player that completed the first objective was provided the information about the stochastic nature of the game.



Figure 33. Screenshot of Round 1, Level 1, Objective 1; Stochastic nature of game mini-message

1.1.1.T

Recall that green squares represent adoption points awarded for the last diffusion activity used. If no adoption points are awarded, no green squares are displayed. What happens to the squares from previous turns? In Level 1 as it existed in Round 1, the points awarded in earlier turns were represented in the same manner as they were in the original DSG. That is, they changed to red. Consider Figures 33 and 34 as an example. In Figure 33, the player just used the “Observe Study” activity which resulted in no points for David. Therefore, no new green squares appeared and all squares that had appeared from earning adoption points in previous squares turned red.

The next turn (Figure 34), the player used “Observe Class” and this time gained one adoption point for David, shown in green. All previous points were then displayed in red.

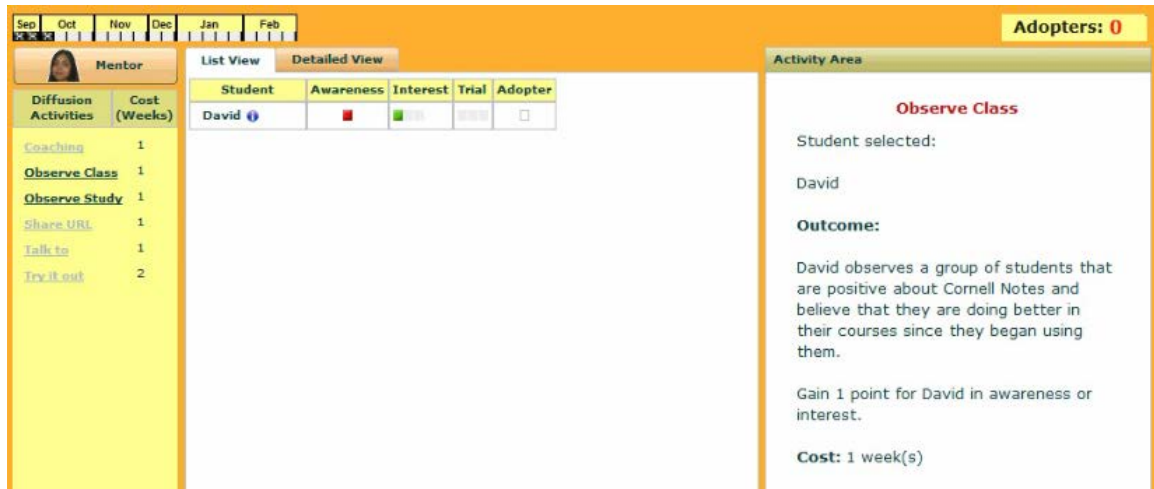


Figure 34. Screenshot of Round 1, Level 1, Objective 1; Red and green squares

Several bugs existed during the first round of the study. One example can be seen in Figures 33 and 34 where the outcomes of the “Observe Class” activity and of the “Observe Study” activity are reversed. The majority of these errors were fixed prior to Round 2 of the study.

1.1.1.U

A mini-message (Figure 35) is provided to the learner once David reaches the Trial stage which again tells the player which activities are most appropriate for David’s current phase of adoption. In this case, “Coaching” and “Try it out” are appropriate for the Trial Phase because they provide David the opportunity to use the innovation on a trial basis. Again, the activities which are appropriate become enabled at this point while the activities which are not appropriate become disabled.

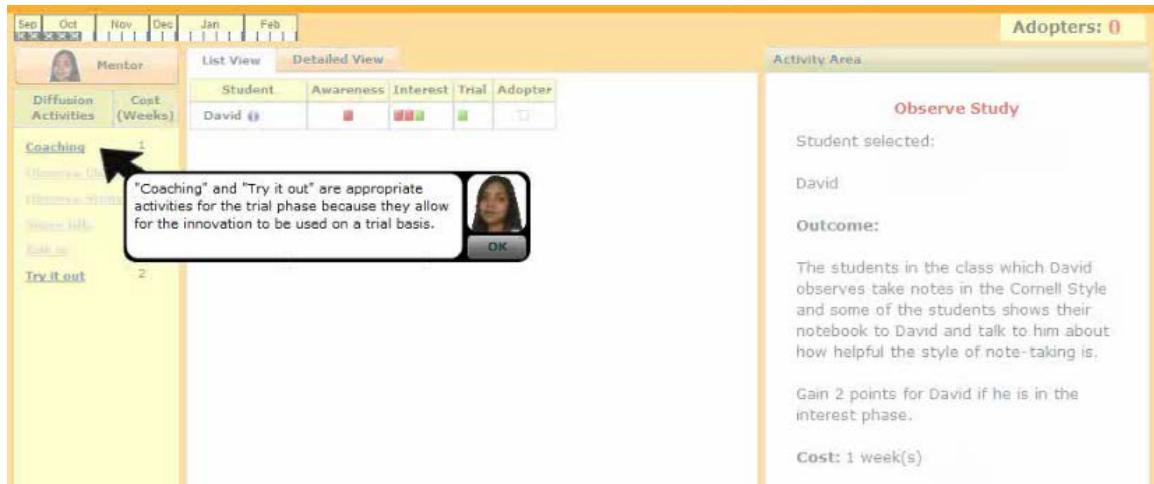


Figure 35. Screenshot of Round 1, Level 1, Objective 1; Activities appropriate for the Trial Phase mini-message

1.1.1.1.V

Once an individual has moved through the Awareness, Interest, and Trial phases of the diffusion-decision process in the game, a green check appears as an indicator that they have adopted the innovation (Figure 36). At this point, all the activities are disabled and a “Continue...” button appears in the Activity Area.

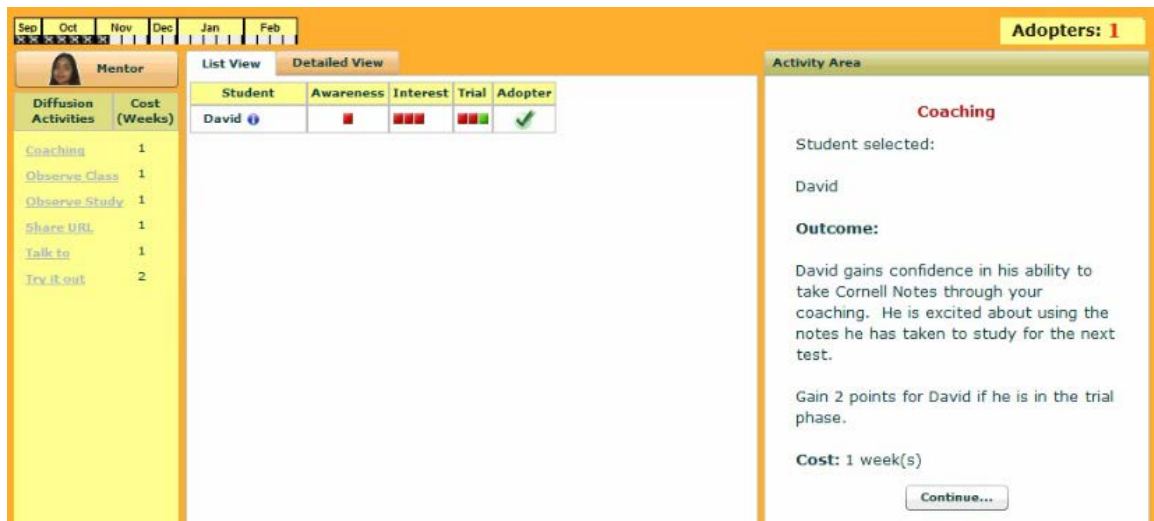


Figure 36. Screenshot of Round 1, Level 1, Objective 1; Getting an adopter

1.1.1.W

Once David has adopted the innovation and the player presses the “Continue...” button, a final mini-message is provided which congratulates them on completing their objective (Figure 37) while also pointing to the area on the screen which shows the current number of adopters. Note that the Round 1 version of the re-designed DSG forces the player to make appropriate game choices and therefore always ends with the player successfully completing the objective. Notice that in this case, the player completed the objective in only seven game weeks.



Figure 37. Screenshot of Round 1, Level 1, Objective 1; Completing the objective

1.1.2 (Round 1, Level 1, Objective 2)

1.1.2.A

Once the player pressed the “OK” button on the final mini-message of Objective 1, they were re-directed to a new URL where the second objective could be played. Just as with the first objective, Objective 2 started with an empty Mentor Window covering the game space (Figure 38). Participants did not notice the changing URL while playing the game. Having a different URL for each objective made it very easy for the researcher to jump quickly from objective to objective (without playing through all previous levels)

which simplified development, quality assurance (QA) testing, and discussion of the game during post-game interviews.

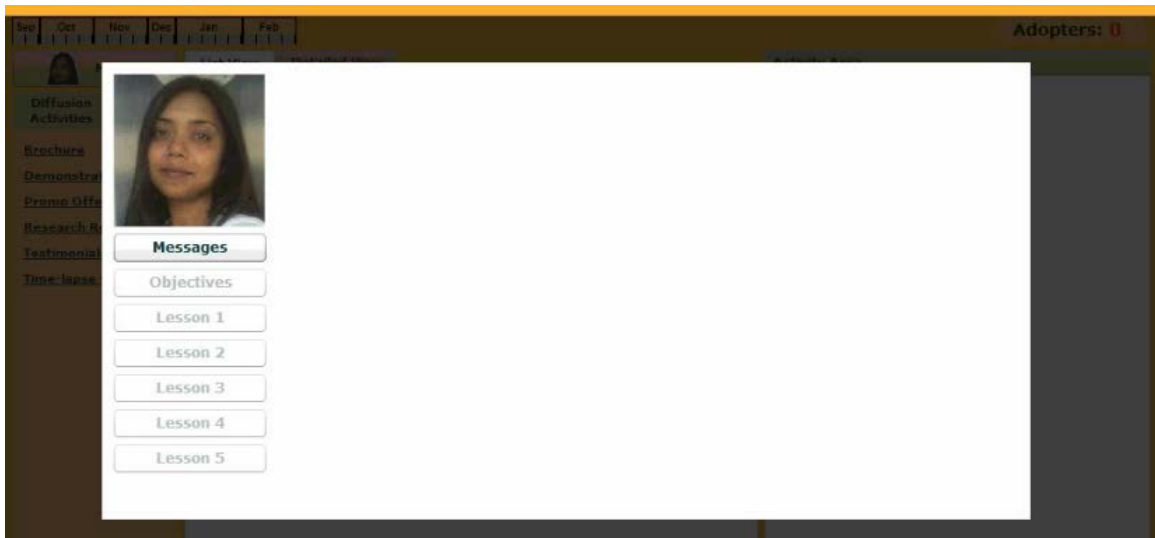


Figure 38. Screenshot Round 1, Level 1, Objective 2; Starting the next objective

In the same manner as Objective 1, players are forced to view the entry message and new objective prior to starting the game by means of disabling and enabling buttons in the desired sequence.

1.1.2.B

When the player presses the “Messages” button they are provided with a congratulatory message from the mentor (Figure 39). This message tells the player that they will be provided with less help in the next objective.

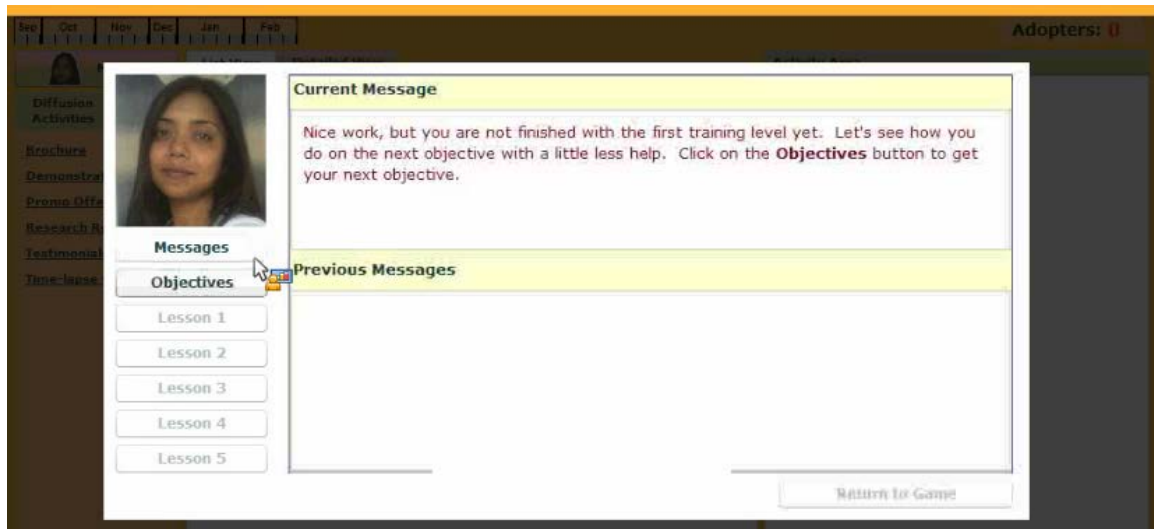


Figure 39. Screenshot Round 1, Level 1, Objective 2; Introduction message

1.1.2.C

When the player clicks on the “Objectives” button, the description of the new objective is displayed: “Get Micah to Adopt Xtreme Conditions paint” (Figure 40). Also notice in the figure that the previous objectives are listed in the lower half of the window under “Completed Objectives”.

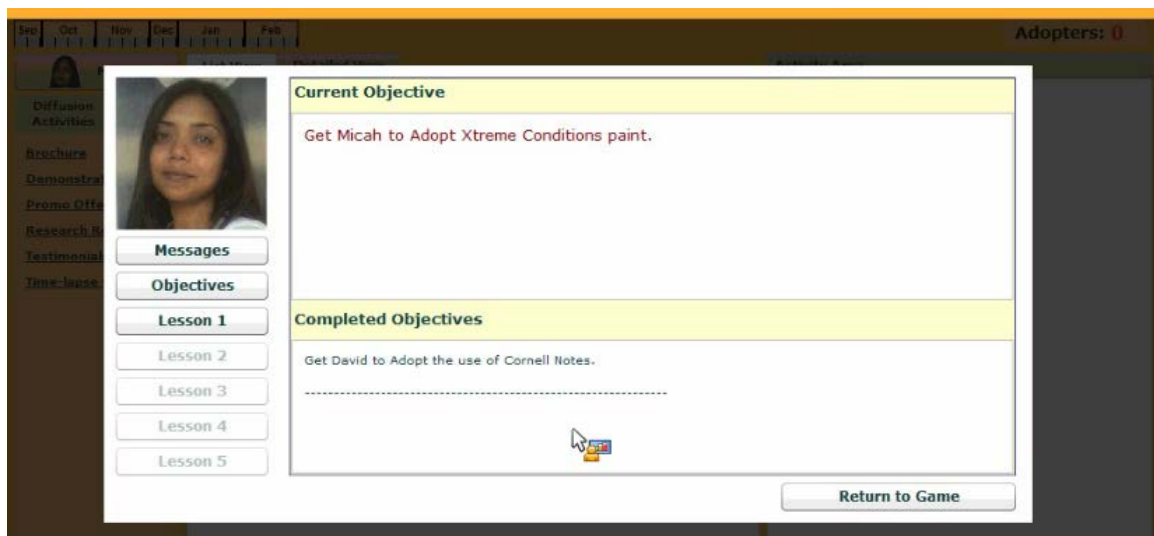


Figure 40. Screenshot Round 1, Level 1, Objective 2; Objective description

Upon clicking the “Objectives” button, both the “Lesson 1” button and the “Return to Game” button are enabled. This allowed the player the option of skipping over the first lesson which they already watched in the first objective.

1.1.2.D

Because the player has already become familiar with the game interface, and because the instructional support was reduced after the first objective, Objective 2 has far fewer mini-messages than Objective 1. Upon closing the Mentor Window, the player is immediately able to begin gameplay without reading any mini-messages. Notice that the Objective 2 game interface (Figure 41) is the same as the interface in Objective 1. However, the individual that the player is to persuade (Micah), his personal information, and the diffusion activities available for persuading Micah have changed to be consistent with the new objective. Providing task variation so that player may apply what they are learning in different situations is a prescription of the TSCL.



Figure 41. Screenshot Round 1, Level 1, Objective 2; Game screen

Also notice in Figure 41 that all of the diffusion activities are enabled. The player must now differentiate between activities that are appropriate for Micah’s current phase of adoption and those which are not appropriate.

1.1.2.E

Just as in the first objective, a mini-message (Figure 42) is displayed the first time a negative outcome results from the player using an appropriate activity to reassure the player that they chose an appropriate activity and that the negative outcome was due to being unlucky. The purpose of repeating this message to players was to address the foreseeable need to reinforce that the game outcomes are stochastic in nature so that players would not prematurely make incorrect conclusions based on outcomes that are not aligned with the appropriateness of the activities they chose.



Figure 42. Screenshot Round 1, Level 1, Objective 2; Stochastic nature of outcomes mini-message

1.1.2.F

In Objective 2, the cumulative number of inappropriate activities used is displayed in the Activity Area underneath the outcome of the activity (Figure 43).

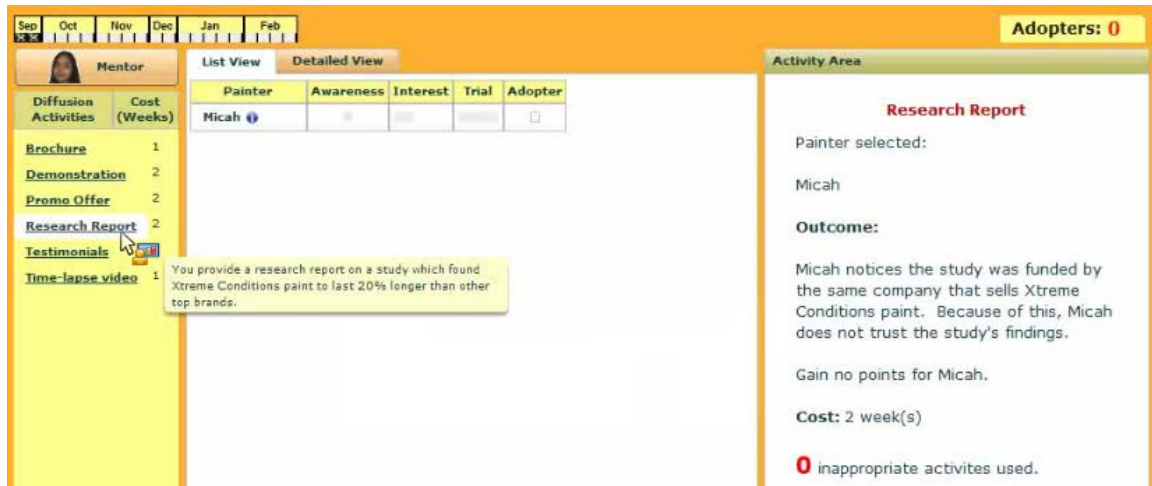


Figure 43. Screenshot Round 1, Level 1, Objective 2; Inappropriate activities used

This element was not introduced in Level 1 because the player was only allowed to make appropriate activity choices, so there was no need to track the number of inappropriate activity choices. The number of inappropriate activities used was shown in red in order to draw attention to this new element and to express the negative connotation of the number. In the case illustrated in Figure 43, the player attempted to move Micah through the Awareness Phase by giving him a Research Report. This activity was appropriate for the Awareness Phase because it provided information about the innovation but the outcome was ineffective. Showing the player that there have been “0 inappropriate activities used” was an attempt at showing them that the activity they used was in fact a good game choice, despite the unlucky outcome. Similarly, players could potentially realize when the activity they chose is inappropriate, without being misled by a lucky (effective) outcome.

1.1.2.G

A recurring issue throughout the first few rounds of the study related to players expectation that once an activity has been used one time with an individual, it would not

be effective if used again. In the game, consecutive uses of the same activity can be effective and is sometimes needed to progress. Consider the situation illustrated in Figure 44.

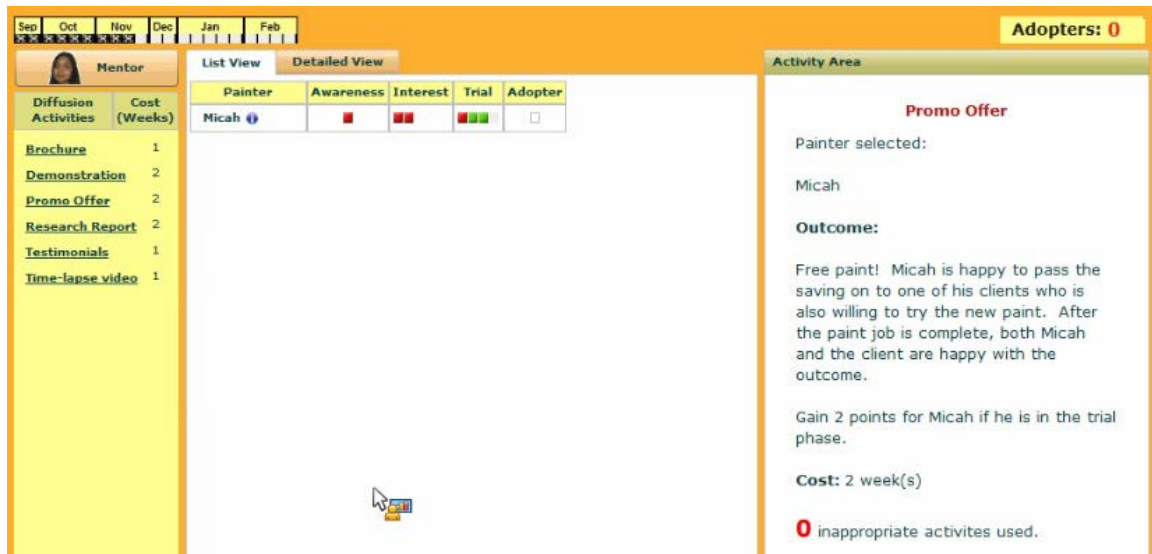


Figure 44. Screenshot Round 1, Level 1, Objective 2; Only one option for Trial

The player used the “Promo Offer” activity successfully, gaining two adoption points in the Trial Phase. The player still needed to gain one point in the Trial Phase for Micah to persuade him to adopt the innovation. However, the only activity in the Diffusion Activities list which provided Micah with an opportunity to try out the innovation was the “Promo Offer”. In this case, the player had to repeat the activity despite any belief that activity should not be effective after the first time they are used with an individual.

1.1.3 (Round 1, Level 1, Objective 3)

1.1.3.A

The third objective, which was the last objective of the level in Round 1, begins in the same manner as the previous two objectives. The player is forced to view the initial mentor message. In this case, the player is informed that they will be provided with no

help (instructional support) during this last objective. The player is then given their new objective to “get Ann to recommend a new diet plan to her clients.” Before closing the Mentor Window, the player has the opportunity to review the Lesson 1 instructional video. Once the player begins the game, they are provided with a new scenario (Figure 45) which includes new diffusion activities, a different innovation to diffuse, a different person to persuade to adopt the innovation, and a different timeline in which to achieve the objective. As prescribed by the TSCL, this last objective of Level 1 requires the learner to apply what they have learned with no instructional support. Therefore, instructional mini-messages and the indicator of the number of inappropriate activities used were omitted from this objective.



Fig 45. Screenshot Round 1, Level 1, Objective 3; Game Screen

1.1.3.B

In Round 1, both the second and third objectives allowed the player to make inappropriate activity choices and therefore the player may not have completed the objective in the time provided. When players ran out of time, they were forced to repeat the objective until they completed it in the allotted time. The completion of the third objective marked the end of the game for Round 1 participants. Players were redirected to the initial screen (Figure 46) of the next level where they could read the initial message

but could not progress further because the other buttons in the Mentor Window remained disabled.

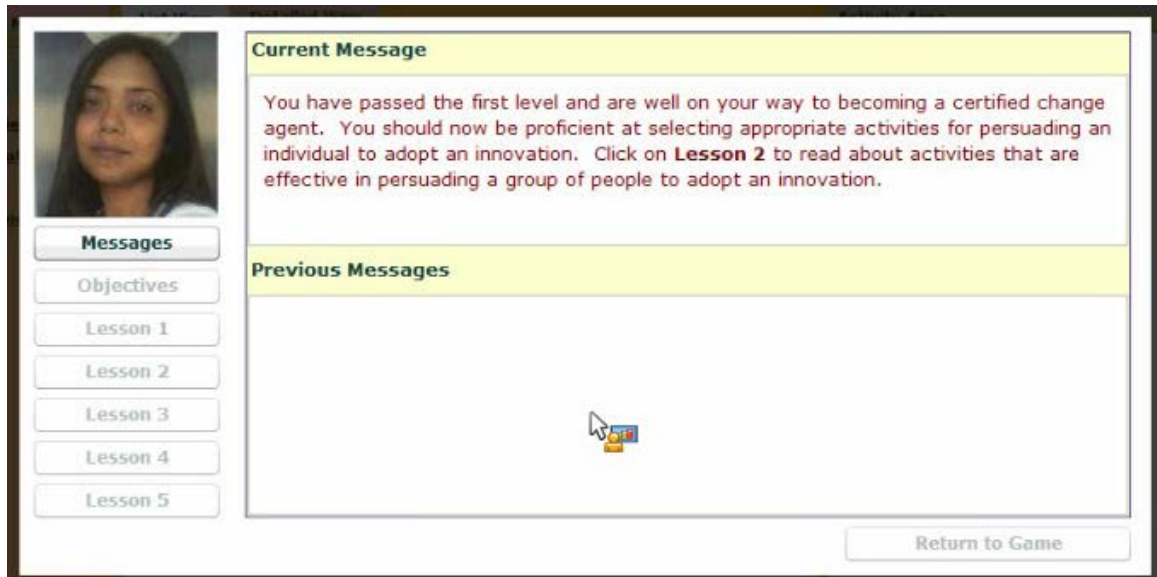


Figure 46. Screenshot Round 1, Level 1, Objective 3; Conclusion of Level 1

Round 1 Findings

The first round of data collection involved four participants playing through the three objectives which made up the first version of Level 1 describe in 1.1.1 through 1.1.3. These participants completed the demographic survey and pre-test, played the first version of the re-designed DSG, completed the post-test, and then answered the concluding interview questions.

All Round 1 participants completed the pre-test prior to playing the game and the post-test afterwards. A total score from the grading rubric (provided in Appendix G) was calculated by giving each mark in the first column a score of zero, each mark in the second column a score of one, and each mark in the last column a score of two. These scores were added up for a total score that could range from 0 to 6.

The resulting scores for Round 1 participants are provided in Table 10 along with the adjusted scores. The adjusted scores account for only the portion of the grading rubric which related to the content covered by the version of the DSG that the participants experienced. In this case, Round 1 participants played through only the first level and were only expected to learn about Adoption Phases so only the top row of the grading rubric was relevant. Therefore, the adjusted score could range from 0 to 2 depending on the score given in the top row of the rubric.

Table 10:

Round 1 Scores of Pre-/Post-tests

Participant	Pre-test	Post-test	Improvement	Adjusted Pre-test	Adjusted Post-test	Adjusted Improvement
1	1	1	0	1	1	0
2	2	2	0	0	2	2
3	2	2	0	0	2	2
4	0	0	0	0	0	0

There was no improvement in participant scores in Round 1 based on the total scores. The average score for both the pre- and post-test was 20.8%. However, when the adjusted scores are considered, the average post-test score of 62.5% was a 50% improvement over the average pre-test score of 12.5%.

The fact that the total scores did not improve while the adjusted scores did reveals that participants performed worse on the post-test for the portion related to the content which was not introduced in the game. This occurred because two of the four

participants omitted effective strategies they had described in their pre-test, possibly because the strategies were not part of their game experience.

The adjusted scores gave evidence that two of the four participants likely learned what was intended from the first level of gameplay and two did not. As the concept of selecting appropriate activities for different phases of adoption is fundamental to the diffusion of innovations theory, it is important that players master this concept before progressing on to the second level. Therefore, instead of beginning the development of Level 2, improvements to Level 1 were made and an additional round of data collection on Level 1 was planned.

The pre-/post-test results were not the only indication of a need to improve the first level before starting to develop the second. Through the recording of the gameplay sessions in which players were encouraged to think-aloud, and through the follow-up interviews, many issues in the initial version of Level 1 were identified. For each of these issues, the author relied on his own design expertise, knowledge of the game content, and technical ability to identify solutions. The issues and corresponding solutions for the first round of participants are provided in Appendix H. Some of these issues were bugs, such as the instructional video playing twice through as described in 1.1.1.F. Some issues were logic errors, such as switching the feedback messages of two diffusion activities as described in 1.1.1.T. More often, however, the issues revealed a flaw in the instructional design.

Participants' game performance was not very meaningful in the first round because there were so many design issues that interfered with fluid gameplay. Several

times in each game session the researcher had to intervene to enable the player to progress in the game. The struggles experienced by players are evident in how long the Round 1 gameplay sessions took which ranged from 19 to 72 minutes.

Participant 4 had the most trouble playing the game during Round 1 and was the only participant in the entire study who scored a 0 on the post-test. This participant did very little “thinking aloud” as she played the game, often did not read the mini-messages or feedback from activities used, and continued to randomly select activities without giving any thought as to whether or not the activity was well-suited for the current phase of adoption. In the follow-up interview, this participant stated “It wasn’t boring. I just didn’t know what I should be doing... I was just clicking on stuff.” The participant also stated “When I think of a game I think of more interaction” and mentioned racing games and killing games as examples. Though other Round 1 participants had a more positive game experience than Participant 4, the need to improve the design of the game to address concerns emerged in all gameplay sessions.

More specific findings that resulted from the Round 1 gameplay sessions and interviews informed the continued design and development of the re-designed DSG that took place in Round 2. Therefore, additional Round 1 findings (particularly those which led to modifications to the re-designed DSG) are described in an integrated manner in the next sections (2.1.1 through 2.1.3).

Chapter 6: Design Case Round 2

The three objectives that were created for Level 1 in Round 1 were retained in Round 2. No additional objectives or levels were created. The modifications that were made to the three objectives are described in the following three sections.

2.1.1 (*Round 2, Level 1, Objective 1*)

2.1.1.A

The first change to Objective 1 involved updating the initial Mentor Message to provide additional information to the player about the game (Figure 47). This change was made to better inform the player what they will be doing in the game — completing four objectives in the first level (though the fourth was not developed at this point). Also by telling the player that there will be much guidance provided in the first objective and that this guidance would be faded in subsequent objectives, the designer hoped to prepare players and increase their tolerance for the large number of mini-messages that appear in the first objective.

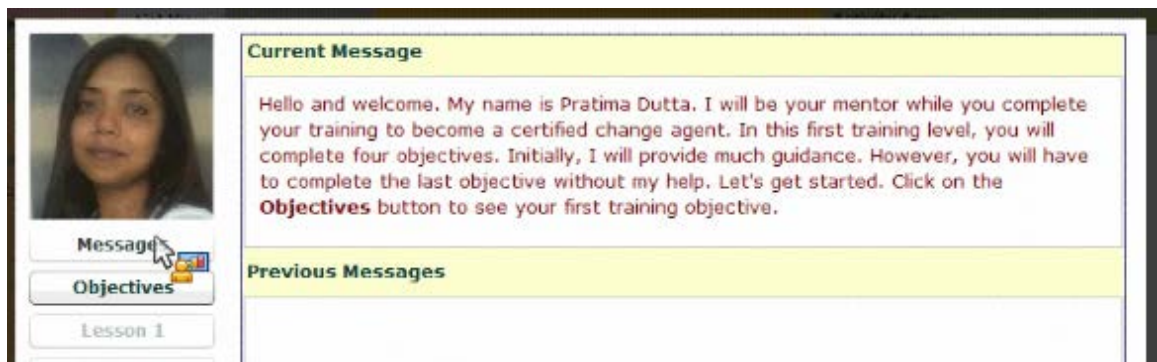


Figure 47. Screenshot Round 2, Level 1, Objective 1; Mentor Window initial message

2.1.1.B

The minimal amount of detail given about each innovation appeared to confuse players in Round 1. Participant 1 stated “I didn’t know what Cornell Notes was so that didn’t help me at all.” Participant 3 also said “I am not sure what is Cornell Notes” upon reading the objective description. Upon seeing the term “Cornell Notes” later in the game, the same participant said “The confusing phrase come back again. I think I still do not have a very clear idea about what’s Cornell Note taking style. I think there is no previous introduction to this phrase.”

To address this lack of expected detail, the objective description of the Mentor Window was updated to give the player more detail about the innovation (Cornell notes) that the player was charged with diffusing (Figure 48). This was done to draw the player more into the game by providing more details about the scenario and to give the player a better idea of what it was they were trying to convince people to adopt so that the goal of the game is clearer.

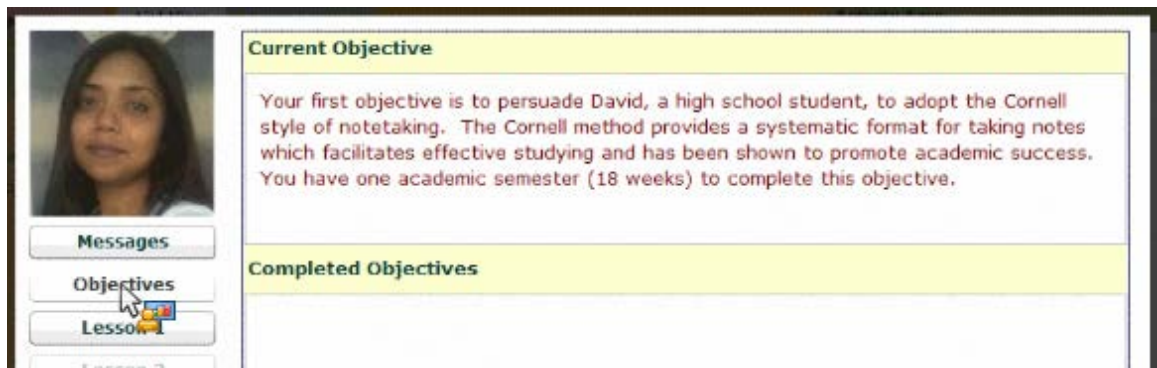


Figure 48. Screenshot Round 2, Level 1, Objective 1; Mentor Window objective description

2.1.1.C

The interface for the Lesson 1 video was also changed in Round 2 (Figure 49). The “Play” and “Pause” buttons were merged into a single button that toggled between “Play” and “Pause” when clicked. The bug (described in 1.1.1.F) related to the video playing twice through was fixed. Lastly, the length of the play bar was extended and tick marks were added to make it simpler for players to keep track of where they are in the video. Though the interface of the Lesson 1 video was improved, the content remained unchanged.



Figure 49. Screenshot Round 2, Level 1, Objective 1; Lesson 1 video

2.1.1.D

Recall that several mini-messages were used in the first objective to tell the player what types of activities were appropriate for each Adoption Phase (illustrated in 1.1.1.J, 1.1.1.R, and 1.1.1.U). These messages were effective in informing Round 1 players which activities were most appropriate for each phase, but not as effective in helping those players understand *why* the activity was appropriate for a particular phase. In

Round 2, these messages were modified to emphasize through bold font style the *why* aspect of the message which Round 1 players did not appear to internalize (Figure 50).

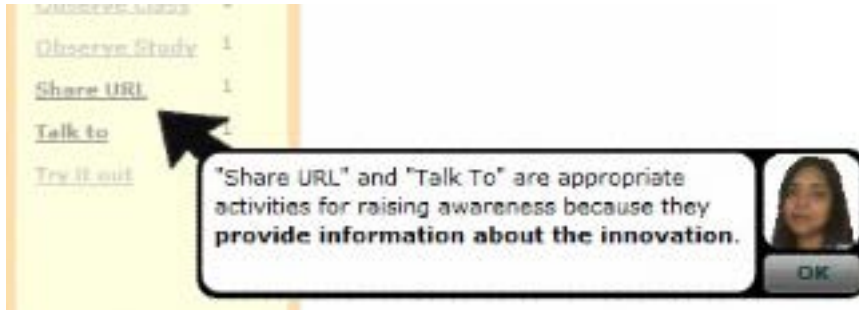


Figure 50. Screenshot Round 2, Level 1, Objective 1; Highlighting important information in mini-messages

2.1.1.1.E

Recall that Round 1 players were forced in the first level to use only appropriate activities for David's current phase of adoption. When players clicked on the links for the activities which were disabled, nothing happened. Despite fading out the links of the disabled activities (1.1.1.I) and providing the player with the initial mini-message that stated they would only be allowed to use appropriate activities (1.1.1.K), some players were confused as to why they were unable to select the disabled activities. In Round 2, the disabled links were modified so that, if clicked on, a mini-message would appear to remind the player that they may only use activities which are appropriate for David's current phase of adoption (Figure 51). In the case illustrated in Figure 51, the player attempted to click on the disabled "Try it out" activity link while David was still in the Awareness Phase. This action caused the reminder mini-message to appear.

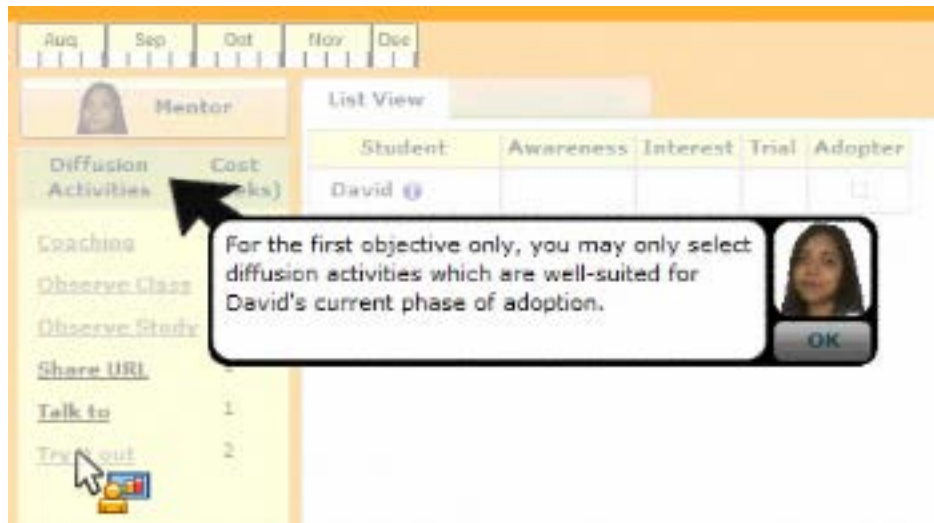


Figure 51. Screenshot Round 2, Level 1, Objective 1; Clicking on disabled activities
2.1.1.F

A significant issue that was revealed in Round 1 was the confusion caused by using red squares to indicate adoption points from previous turns while using bright green squares to indicate the points from the current turn (see 1.1.1.T). The first participant became confused as to which phase of adoption David was in when the squares turned red. Likewise, the second participant responded the first time they saw the green squares turn red by saying “Why did I go red?... I got him sick. Oh man that sucks.” As the second objective was loading, the same participant said “Ok, I gotta tell you. It went green and the other ones turned red, and that frankly to me was a little bit confusing.” Participant 3 also perceived the red squares to be negative and later in the interview asked “Is there any statement telling about why it changed to red?”

Changing the red squares to a faded green square served as the solution for this issue. Figure 52 illustrates the use of green and faded green squares in showing the player’s progress in persuading David to adopt the innovation.

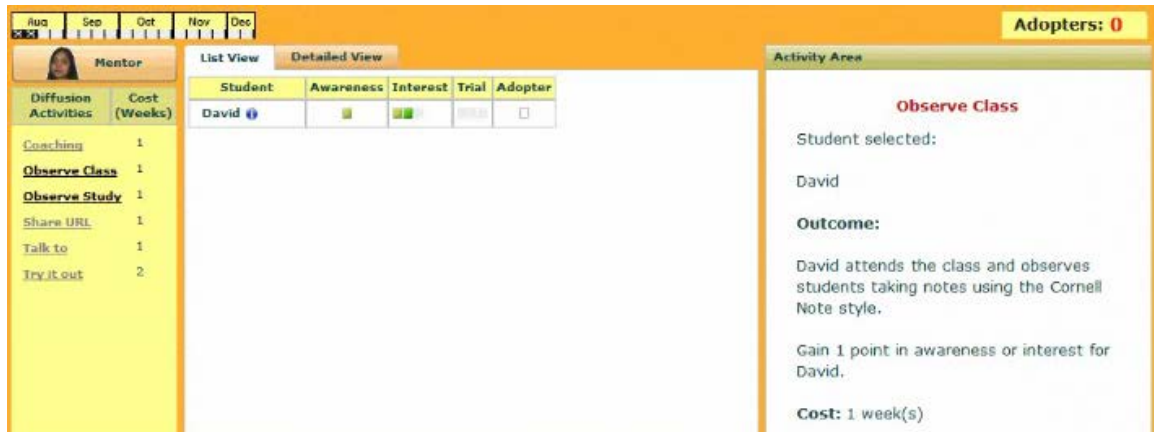


Figure 52. Screenshot Round 2, Level 1, Objective 1; Use of faded green squares

In Figure 52, the player used the “Observe Class” activity which resulted in gaining an adoption point for David. The two faded green squares represent points that were awarded in previous turns. The last green square which is not faded represents the point which was awarded in this turn.

2.1.1.G

Despite efforts made to minimize the distraction to learning caused by the requirement for players to repeat activities with the same individual (1.1.1.S), several players continued to avoid using activities multiple times. For example, in the first objective Participant 1 stated “He already watched the Time-Lapse Video so it does not make sense to have him watch that again.” When the player did finally try the Time-Lapse video again and it was successful, they said “oh, that doesn’t make sense... it doesn’t make sense to show him the same video twice, it doesn’t make sense.” During gameplay, Participant 2 said “I don’t know what to do next” after having already used each diffusion activity once. Participant 2 said later “making the same choice over and over which is frankly a little counter intuitive... but if that’s all you got than that’s all you got and that’s definitely one of those making the best of all I’ve got.” During the

interview, the same participant said “The idea of trying something, and then trying it again, and then trying it again, and it kept getting better the more I tried it... that took me a minute to get my thought process around there.”

To be consistent with the original version of the DSG, the ability to repeat activities was preserved. Instead, the number of boxes in the Trial Phase was reduced so that less repetition of the same activity would be needed.

2.1.2 (Round 2, Level 1, Objective 2)

2.1.2.A

In Round 2, the description of the second objective (Figure 53) was also expanded by adding more detail about the innovation (Xtreme Conditions Paint) which the player must persuade Micah (the painter) to adopt. The reason for providing more detailed information about the innovation in Round 2 was the same as the reason for providing more detailed information in Round 1 (2.1.1.B).

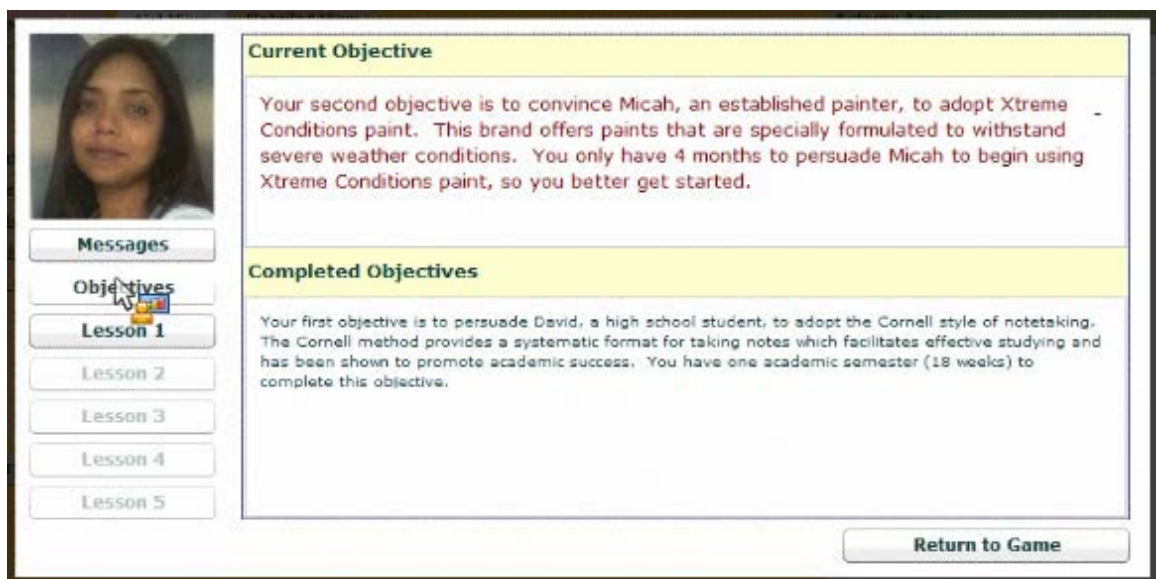


Figure 53. Screenshot Round 2, Level 1, Objective 2; Objective description

2.1.2.B

One strategy for developing effective learning tasks prescribed by the TSCL is to observe the behavior of learners who are successful in completing the task. Observations of gameplay (both from the first round of this study and of several other studies which involved the original DSG), more successful players often took notes and categorized people with different characteristics into meaningful groups; such as putting all people who are open to change in one group and all people who are not in another. To promote the use of this learning activity with all players, a Sort Activities activity was added to Objective 2 which allows players to sort the diffusion activities into categories based on the phase of adoption each activity is best suited for. The mini-message shown in Figure 54 tells players that they have the option of completing this activity.



Figure 54. Screenshot Round 2, Level 1, Objective 2; Sort Activities mini-message

In Round 2, the Sort Activities activity was optional (provided the player did not make too many mistakes). The Sort Activities activity is described in detail in 2.1.2.H, 2.1.2.I, and 2.1.2.J.

2.1.2.C

Recall that mini-messages were used in Round 1 to avoid players forming misconceptions when the appropriateness of an activity they chose was not consistent with the effectiveness of the resulting outcome (1.1.1.S and 1.1.2.E). Also recall that displaying the number of inappropriate activities used (1.1.2.F) was another design decision made in Round 1 to address this concern. Unfortunately, Round 1 participants continued to be confused and misled by the stochastic nature of the game. For example,

Participant 1 stated during gameplay “Well that didn’t make sense. So I clicked promo offer once for trial and it worked. I clicked promo offer twice for trial and it didn’t work. And then I clicked promo offer a third time for trial and it worked. Not sure I understand.”

To address this unresolved issue in Round 2, a Probability Graph was added to the second objective to make it clear to players that the results of their actions had an element of randomness. The Probability Graph appears, along with a mini-message introducing the new game element (Figure 55), when the player first selects an activity in Objective 2.



Figure 55. Screenshot Round 2, Level 1, Objective 2; Probability Graph mini-message
2.1.2.D

The Probability Graph allows the player to see the probability of getting effective outcomes for each activity, depending on Micah’s current Adoption Phase. For example, in Figure 56 the Probability Graph tells the player the probability of the Brochure being effective (green), somewhat effective (yellow), or not effective (red) when Micah is in the Awareness Phase. In this case, there are three possible outcomes each with the same probability of occurring.

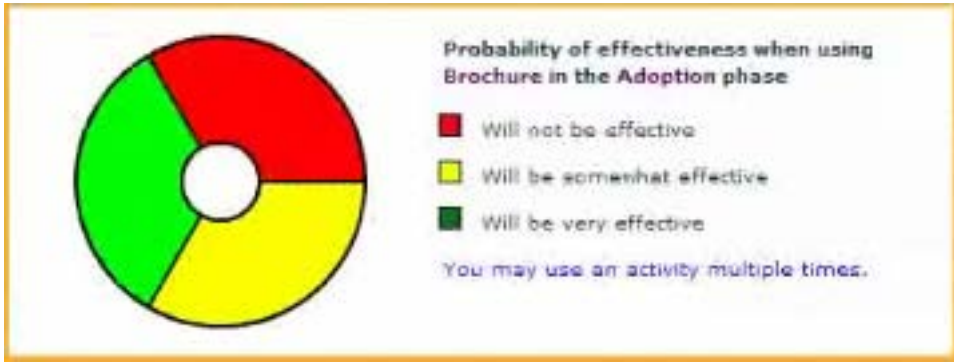


Figure 56. Screenshot Round 2, Level 1, Objective 2; Probability Graph for Brochure in the Awareness Phase

Note that in Figure 56, “in the Adoption phase” should have read “in the Awareness phase”. This is just one of many examples in which a typo was revealed in the study and fixed prior to the participants of the next round playing the game.

Also notice the blue text in Figure 56 which states “You may use an activity multiple times.” This text, as well as the Probability Graph itself was intended to give additional reinforcement to the idea that activities can be effective even though they have already been used before.

2.1.2.E

Figure 57 illustrates another example of the Probability Graph in use. In this case, the player selected the Demonstration activity while Micah was in the Interest Phase. The resulting Probability Graph shows that there were five possible outcomes; two of which are not effective, two of which are somewhat effective, and one of which is very effective. The Activity Area shows the outcome the player received by using the activity, which in this case was not effective (Micah gained no points).

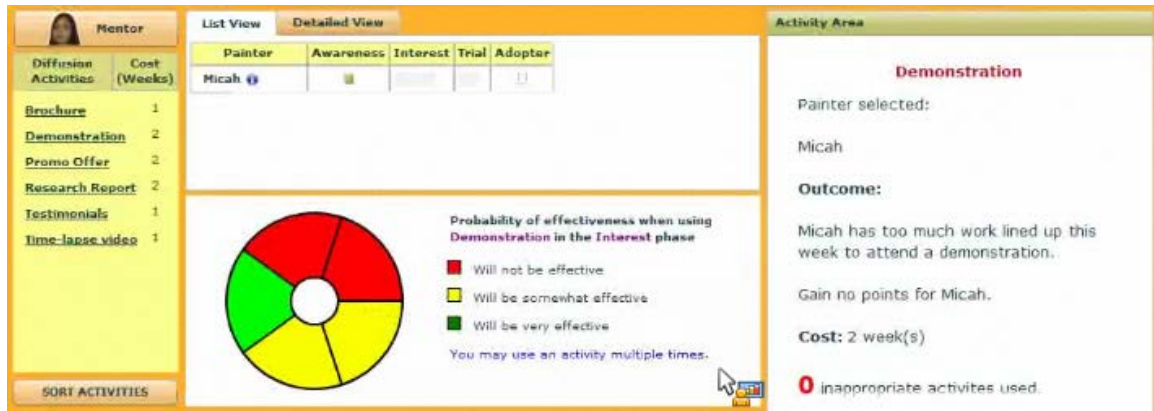


Figure 57. Screenshot Round 2, Level 1, Objective 2; Probability Graph for Demonstration in the Interest Phase

2.1.2.F

Activities that are appropriate for Micah's current phase of adoption have much more chance of being somewhat or very effective. Activities which are inappropriate for Micah's current phase of adoption are more likely to be ineffective. In some cases, such as the one depicted in Figure 58, there is no chance of the activity being effective for Micah's current phase of adoption.

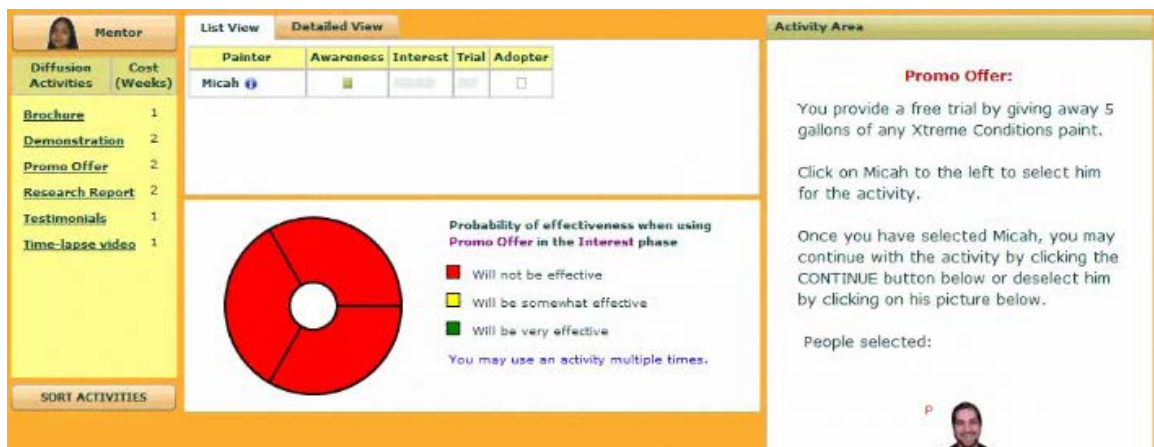


Figure 58. Screenshot Round 2, Level 1, Objective 2; Probability Graph with for an activity which has no chance of being effective

2.1.2.G

If the player makes 3 inappropriate activity choices in Objective 2, a mini-message appears stating “It looks like you could use some help choosing appropriate activities for Micah’s current phase of adoption.” This message is immediately followed by another mini-message which either tells the player that they must complete the Sort Activities activity (Figure 59), or if they have already done so, tells the player that they must review the Sort Activities activity. In both cases, the Sort Activities activity opens when the player presses the “OK” button on the mini-message.



Figure 59. Screenshot Round 2, Level 1, Objective 2; Too many errors mini-message

Consider the situation illustrated by Figure 59. The player attempted to use a Research Report to persuade Micah, who is in the Trial Phase, to adopt the innovation. This activity is not appropriate for the Trial Phase because it does not give Micah the opportunity to use the innovation on a trial basis. As expected, the outcome in the Activity Area shows that the activity was not effective. Regardless of whether or not the activity would have been effective, it was not appropriate for Micah’s current phase of adoption. As shown at the bottom of the Activity Area, this was the third inappropriate

activity used in this objective. Therefore, this action led to the mini-messages telling the player they need to complete, or review, the Sort Activities activity.

2.1.2.H

The Objective 2 Sort Activities activity requires the player to drag each Objective 2 diffusion activity into the appropriate phase of adoption (Figure 60). The description under each of the Adoption Phase headings provides the player with the key information they need to consider to correctly sort the activities. The “Return to Game” button remains disabled until the player correctly sorts all the diffusion activities into their appropriate Adoption Phases. The blue text which tells the player to “Drag activities to the most appropriate phase of adoption” disappears once all activities have been moved out of the first column. The red text tells the player that “One or more activities are under the wrong phase of adoption”.

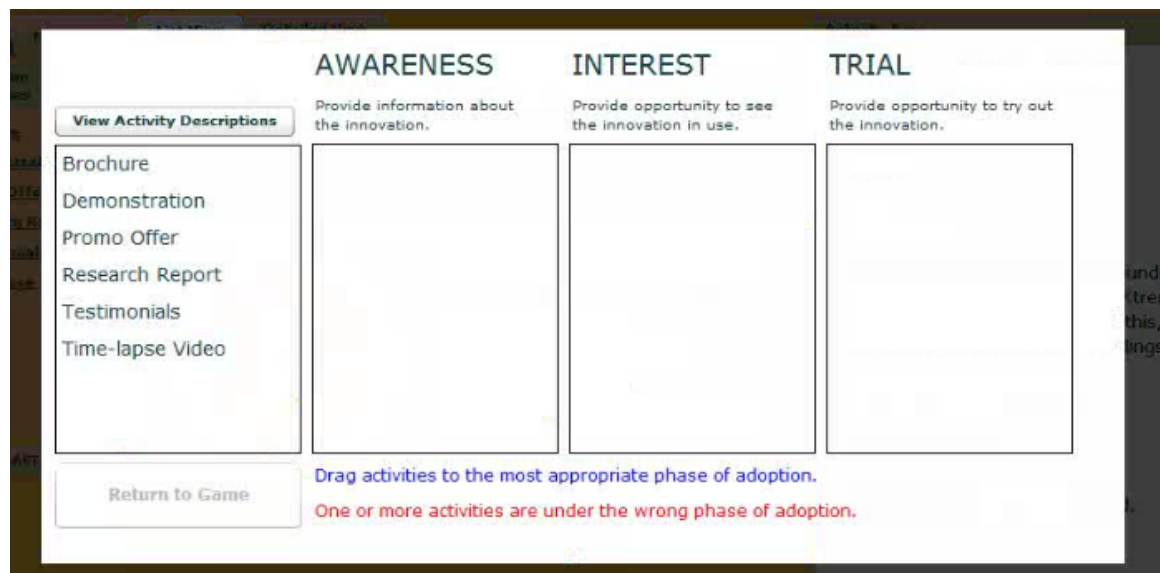


Figure 60. Screenshot Round 2, Level 1, Objective 2; Sort Activities activity

The Sort Activities activity is a form of part-task practice (as defined by the TSCL) because it takes the player out of the whole task (persuading Micah to adopt

Xtreme Conditions paint) in order to practice part of the whole task (identifying which activities are appropriate for each phase of adoption).

2.1.2.I

The “View Activity Descriptions” button in the Sort Activities activity allows players to review the descriptions of each diffusion activity (Figure 61). This is important because players need to consider how the activity is used to determine which phase of adoption it is most appropriate for. Also, because the player cannot exit the Sort Activities activity until it has been correctly completed, the descriptions which are in the game are not accessible to the player.



Figure 61. Screenshot Round 2, Level 1, Objective 2; Descriptions of diffusion activities in Sort Activities activity

2.1.2.J

Upon sorting each activity correctly, the red text stating that some of the activities are not sorted correctly is replaced by green text stating that all the activities have been

correctly sorted (Figure 62). At this point, the “Return to Game” button becomes enabled.



Figure 62. Screenshot Round 2, Level 1, Objective 2; Activities sorted correctly

2.1.2.K

After the player exits the Sort Activities activity for the first time, a mini-message is used to tell the player that they can review their work at any time during the objective (Figure 63) by clicking on the button (previously labeled “SORT ACTIVITIES”) whose label has been updated to say “REVIEW ACTIVITIES”.

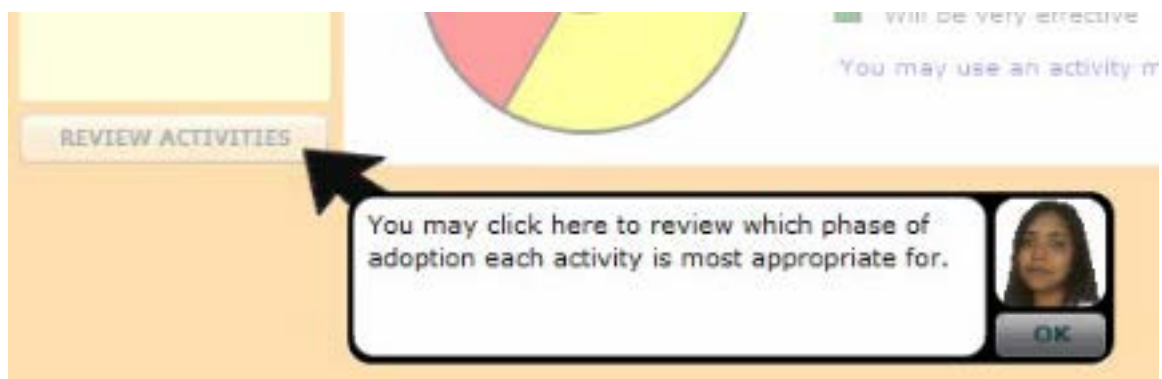


Figure 63. Screenshot Round 2, Level 1, Objective 2; Review Activities mini-message

2.1.3 (Round 2, Level 1, Objective 3)

2.1.3.A

Just as in Round 1, in Round 2 the third objective was the last objective of Level 1. As such, almost no instructional support was provided to the player. This was made known to the player immediately through the initial message in the Mentor Window which stated “You completed the second objective with no mistakes! I think you are ready to complete the next objective without my help. Good luck!”

As with Objective 1 and Objective 2, the description of Objective 3 was expanded in Round 2 to provide the player with more information about the innovation (Figure 64). Because the objective descriptions were longer in Round 2, a scroll bar was added to the “Completed Objectives” so that players could review the full description of the objectives they had already completed.

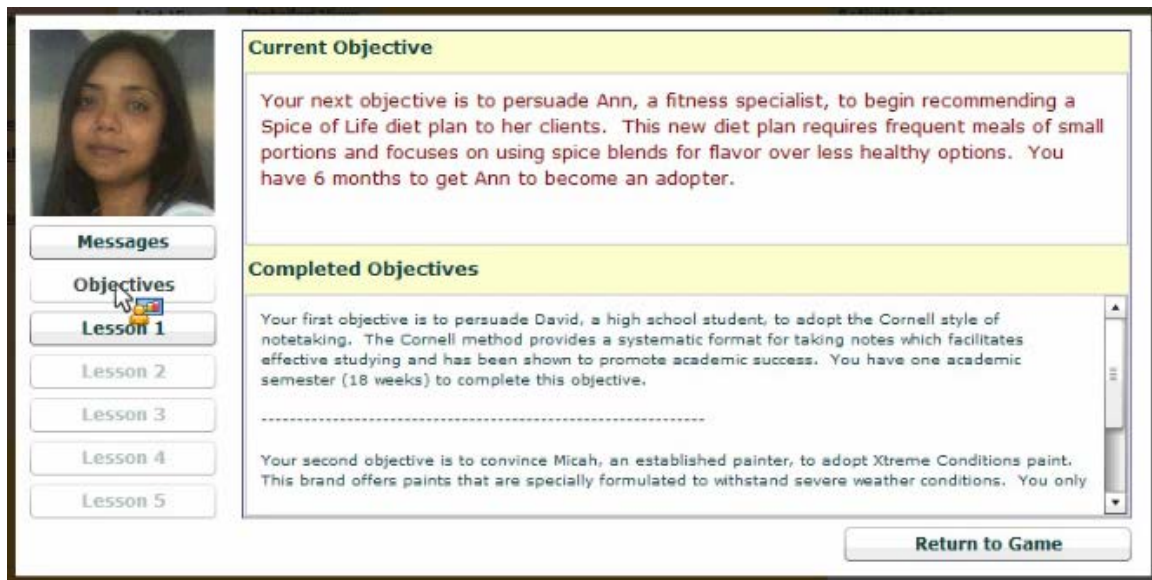


Figure 64. Screenshot Round 2, Level 1, Objective 3; Objective description

2.1.3.B

Figure 65 shows the game screen for Objective 3 with the Detailed View tab selected. As the final objective of Level 1, this objective initially provided the player with very few mini-messages and no Sort Activities activity or Probability Graph.

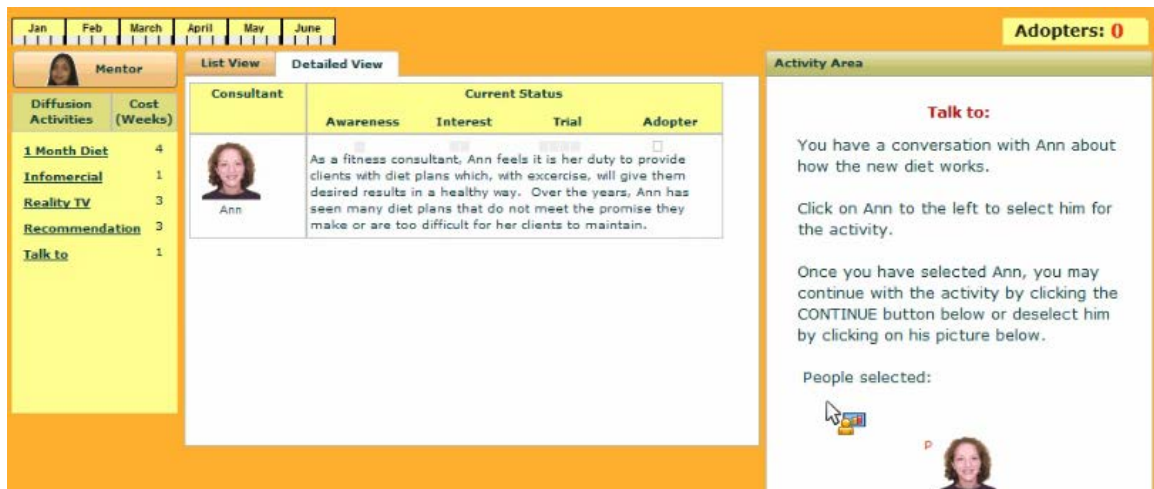


Figure 65. Screenshot Round 2, Level 1, Objective 3; Game screen in Detailed View

However, because the researcher had to intervene several times in Round 1 to help players who were completely stuck on the last level, some instruction was included as corrective feedback once the player made three errors in selecting appropriate activities for Ann's current phase of adoption (Figure 66).

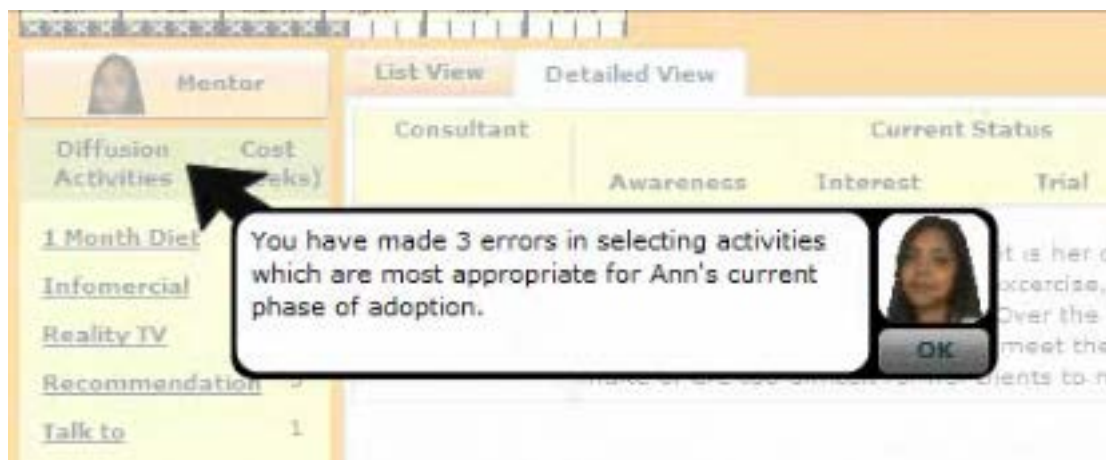


Figure 66. Screenshot Round 2, Level 1, Objective 3; Mini-message after three errors

Upon pressing the “OK” button of the mini-message, the “SORT ACTIVITIES” button appears on the game screen along with another mini-message telling the player that they must complete the Sort Activities activity and then start the objective over (Figure 67).

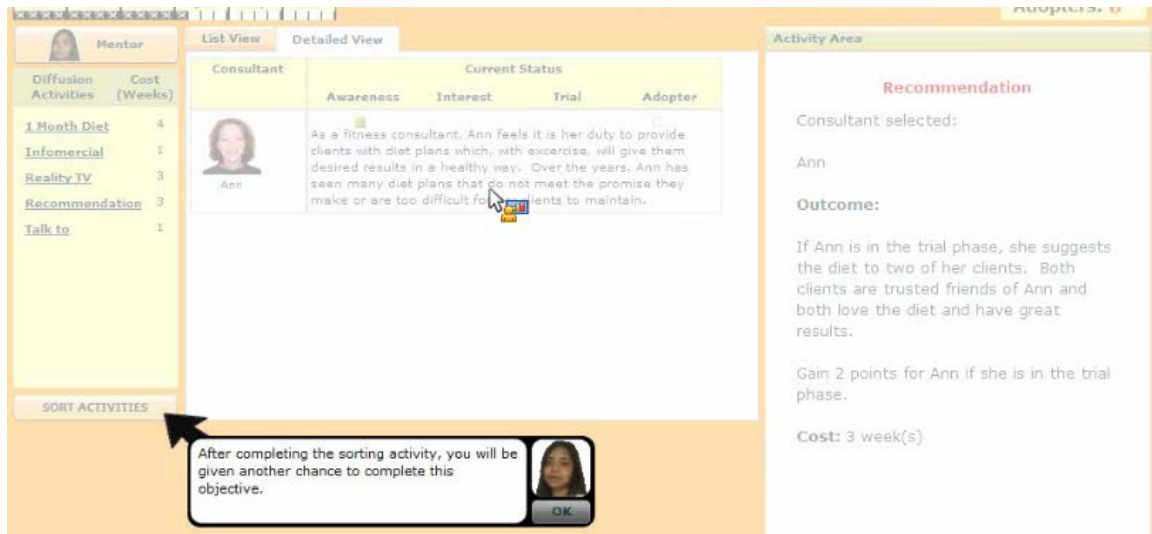


Figure 67. Screenshot Round 2, Level 1, Objective 3; Mini-message starting objective over

2.1.3.C

The Sort Activities activity that was added to Objective 3 (Figure 68) is the same as the Sort Activities activity that was added to Objective 2 (described in 2.1.2.H through 2.1.2.J), except that the diffusion activities and the descriptions of the diffusion activities were updated to match those of the current objective. Once the Sort Activities activity is successfully completed, the “Return to Game” button becomes enabled. However, unlike Objective 2, when the “Return to Game” button is clicked, the objective is reloaded without the “SORT ACTIVITIES” button and the player must start the objective over. In this way, the player must complete the final objective by making fewer than three poor activity choices.

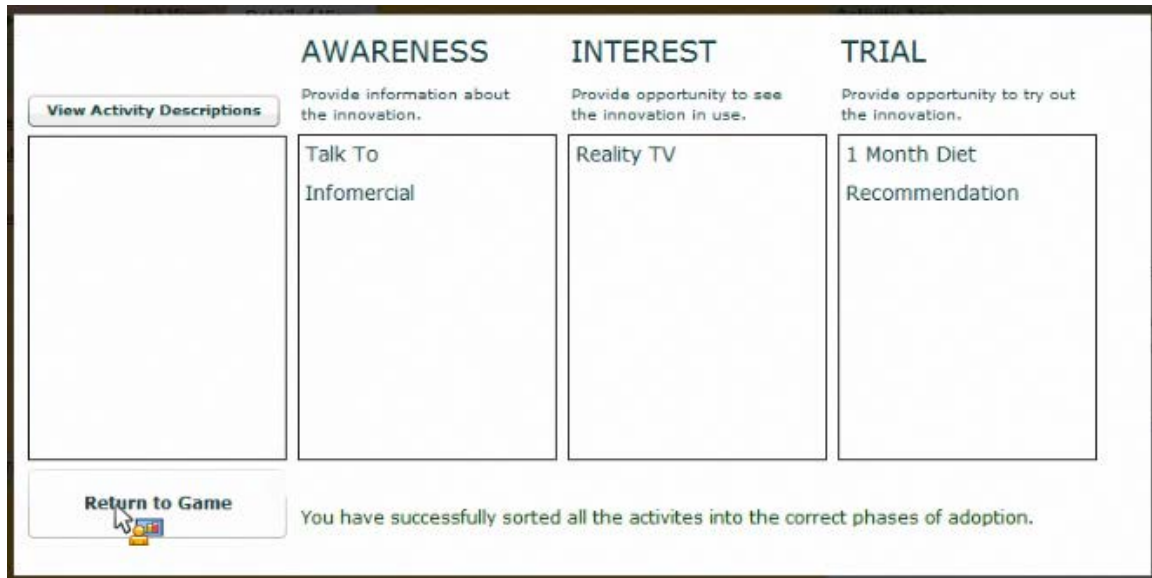


Figure 68. Screenshot Round 2, Level 1, Objective 3; Sort Activities activity

Round 2 Findings

Feedback from Round 2 participants was generally positive about the game. For instance, participant 6 stated that “I feel like I really learned something today... I think it has a lot of potential to be applied to the real world.” Participant 5 said “I thought it was appealing because it makes you think and it’s not an easy game but it’s a doable game and especially now that I know how it operates, it’s very engaging. I think I would learn a lot more after going through it a couple of times.”

Feedback about the mini-messages was a bit more mixed. Participant 5 felt the mini-messages were very helpful. Likewise, participant 7 said “I like the mini-messages very much and I like that there was a pleasant person to see.” However, the same participant also stated later that “it would be kind of nice instead of having programmed instruction [the mentor] to have access to a living, breathing human being.” Participant 6 noted that they liked the mini-messages “as long as it does not continue on”.

The three participants in the second round of data collection played an improved version of the first level which still consisted of three objectives. The time spent playing the game ranged from 24 to 48 minutes. Again, all three participants completed the pre-test prior to playing the game and the post-test afterwards. A total score from the grading rubric (provided in Appendix G) was calculated in the same manner as Round 1 for a total score that could range from 0 to 6.

Inadvertently, the pre- and post-test of Participant 6 was lost. The scores for the other two participants are provided in Table 11 along with their adjusted scores. Again, participants of Round 2 played through only the first level and were only expected to learn about Adoption Phases through their gameplay so only the top row of the grading rubric was relevant. Therefore, the adjusted score could range from 0 to 2 depending on the score given in the top row of the rubric.

Table 11:

Round 2 Scores of Pre-/Post-tests

Participant	Pre-test	Post-test	Improvement	Adjusted Pre-test	Adjusted Post-test	Adjusted Improvement
5	0	2	2	0	2	2
7	0	1	1	0	1	1

Both participants scored no points on the pre- or post-test for the portions of the rubric (rows 2 and 3) which tested concepts not introduced in the version of the game that was played. This is the reason that the pre- and post-test scores are the same as the adjusted pre- and post-test scores in Table 11. The mean total post-test score of 25% (1.5

out of 6 possible) was a 25% improvement over the mean total pre-test score of 0%. The mean adjusted post-test score of 75% (1.5 out of 2 possible) was a 75% improvement over the mean adjusted pre-test score of 0%.

The 75% mean improvement between the mean adjusted pre-test score and the mean adjusted post-test score suggests that players learned, at least in part, the concept of Adoption Phases and how to select appropriate activities for each Adoption Phase. Still, because the concept is so fundamental to the diffusion of innovations theory, and because data from the interviews and gameplay session revealed additional issues with the design, the author decided to once again focus on improving Level 1 before beginning any development on Level 2.

The issues that were revealed during Round 2 and the attempted solutions to those issues were documented in the same way as in Round 1 (see Appendix H), but are not included in this paper due to the large amount of data. The findings that resulted from the Round 2 gameplay sessions and interviews informed the continued design and development of the re-designed DSG that took place in Round 3. Therefore, additional Round 2 findings (particularly those which led to modifications to the re-designed DSG) are described in an integrated manner in the next sections (3.1.1 through 3.1.4).

Chapter 7: Design Case Round 3

The three objectives in the first level of Rounds 1 and 2 appeared to be insufficient in providing players with a complete understanding of how to identify activities which are most appropriate for each phase of adoption. In Round 3, a fourth objective was added to give players additional practice at applying the concepts to be learned, and to provide them with a more gradual reduction of instructional support.

Additionally, the fourth objective was added to give players the opportunity to apply what they had learned with more than one individual. In the initial design (prior to Round 1) outlined in Appendix A, a separate level was designed to allow players to apply the concept of Adoption Phases to groups of people instead of individuals. However, to remove the need to develop an entire level for this purpose, the fourth objective of Level 1 was designed and developed. Replacing the additional level with a single objective was intended to lessen the development time significantly and lessen the amount of time learners would need to play the game.

3.1.1 (*Round 3, Level 1, Objective 1*)

3.1.1.A

The first change made to Level 1 in Round 3 was to remove the initial blank screen (discussed in 1.1.1.A) which confused some players and, instead, immediately start the game with the Messages screen of the Mentor Window (Figure 69).

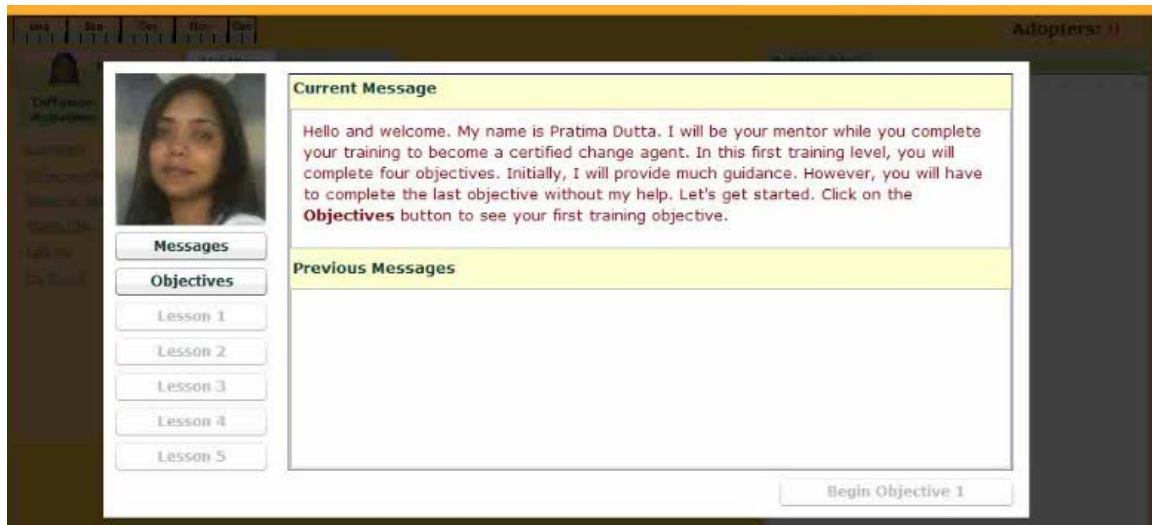


Figure 69. Screenshot Round 3, Level 1, Objective 1; Initial screen

3.1.1.B

Another change that the Round 2 data analysis led to was the reduction in length and content of the instructional video from 3'47'' to 2'09'' (Figure 70). Reducing the video length was in part due to participants' reaction to the video. Participant 6, for example, said "That was pretty long winded" after finishing the video and participant 7 agreed during their interview that the video should be cut in half. More so, however, providing a more concise video was a means to help players focus on the key concepts that they should be learning: activities that provide information about the innovation are best for the Awareness Phase, activities that allow the person to see the innovation in use are best for the Interest Phase, and activities that allow the person to try out the innovation are best for the Trial Phase. The need to be more concise was apparent through some of the participants' comments. For example, Participant 5 said "Actually [the video] was a precursor to what was going on during the video game, but I didn't put one and one together." Participant 4 from the previous round, had trouble making a connection between the video and the game until the very end of the video and stated in

the interview “I think that by this point, because it was 3 minutes into the video and I’m learning a new process, it was just so much information at once, that by the time I got here, I was hearing it but was not processing what was going on.” Reducing the content in the video was an attempt to improve the appeal of the video and, more importantly, focus the player’s attention on the information that is most important for them to learn.

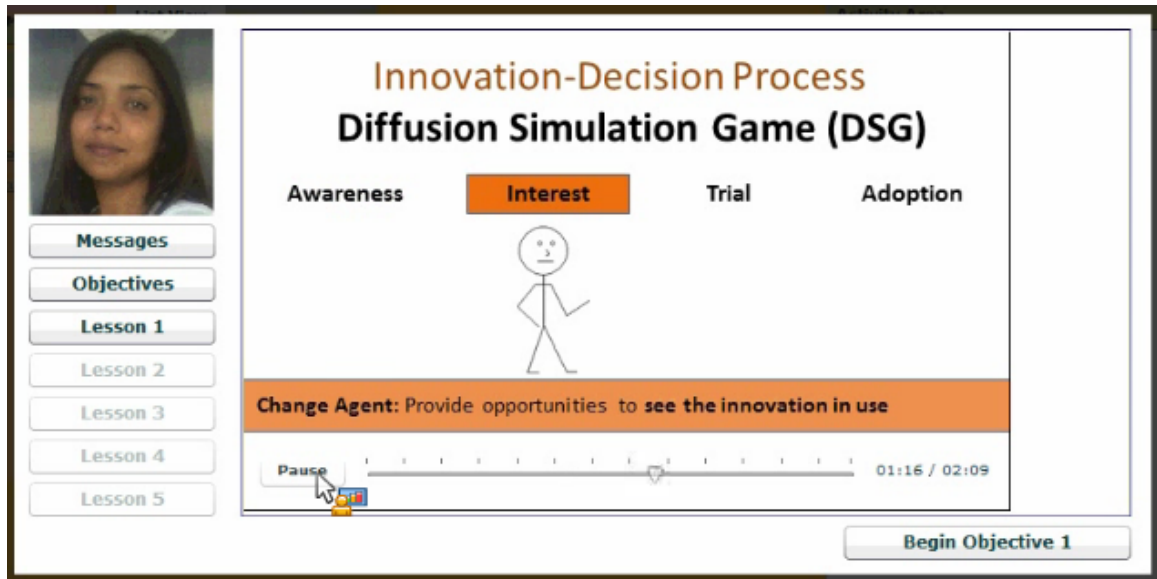


Figure 70. Screenshot Round 3, Level 1, Objective 1; Shortened Lesson 1 video

3.1.1.C

In addition to making the Lesson 1 video more concise, recreating the video gave the developer the opportunity to add a visual representing the mental model (Figure 71) which the player needs to have to effectively complete the tasks in Level 1. This mental model consists of the most fundamental concept of the Diffusion of Innovations which Level 1 of the game was designed to deliver.

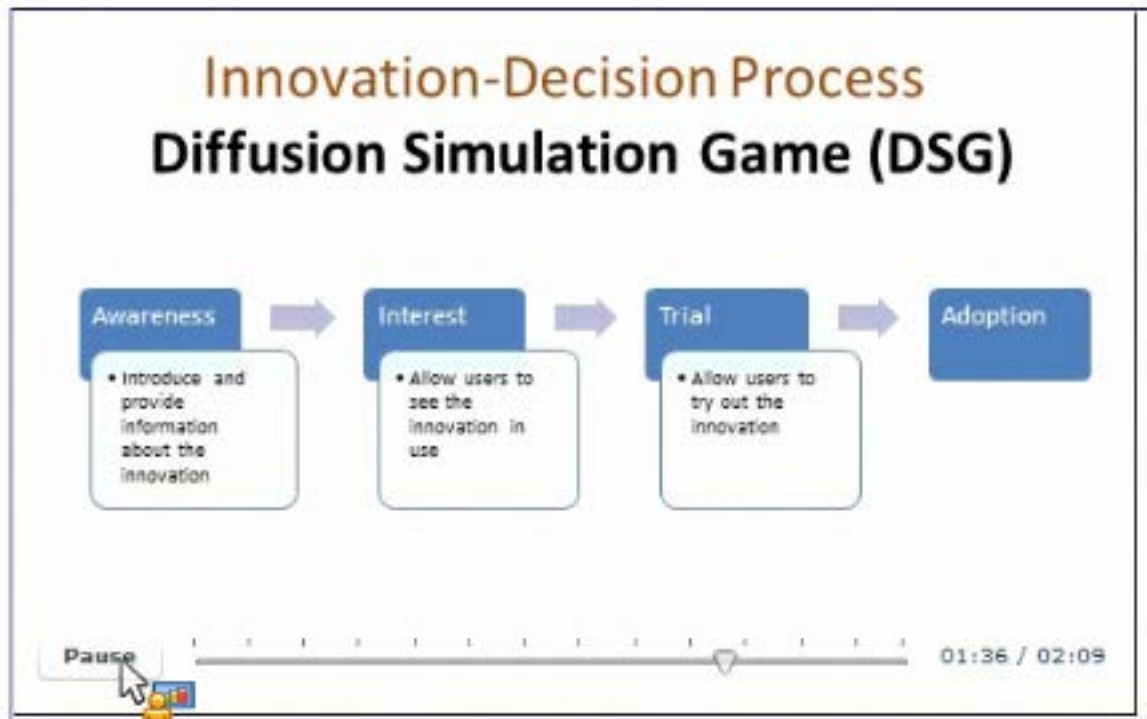


Figure 71. Screenshot Round 3, Level 1, Objective 1; Mental model within Lesson 1 video

3.1.1.D

Many players had difficulty using the definitions of *Awareness* and *Interest* that were provided in the game. Instead, players selected activities which they believed to be more appropriate for the three Adoption Phases based on their own understanding of how to raise awareness and interest in the real world. In Round 2, these definitions were provided in the Lesson 1 video (1.1.1.E), through mini-messages (2.1.1.D), and in the sorting activities (2.1.2.J and 2.1.3.C). In Round 3, these game definitions were further emphasized in the video with the addition of the mental map (Figure 71) and by providing learners with roll-over information for each of the Adoption Phase headings (Figure 72).



Figure 72. Screenshot Round 3, Level 1, Objective 1; Mouse-over information for Adoption Phase headings

3.1.1.E

The issue of players making premature conclusions based on a single instance of using a particular strategy for a particular Adoption Phase was persistent in Round 2. Related to this concern was the issue that players became frustrated and/or confused when activities worked in an inconsistent manner. Participant 6, for example, said “This is getting irritating; I don’t know which one works and which one doesn’t”.

The Activity Log (Figure 73), initially labeled “APPROPRIATE ACTIVITY CHOICE”, was introduced in Round 3 to further promote players’ understanding that an activity which was ineffective could have been appropriate, and an activity which was effective could have been inappropriate. The Activity Log displays a smiley face for each appropriate activity used by the player and a red X for each inappropriate activity used by the player.

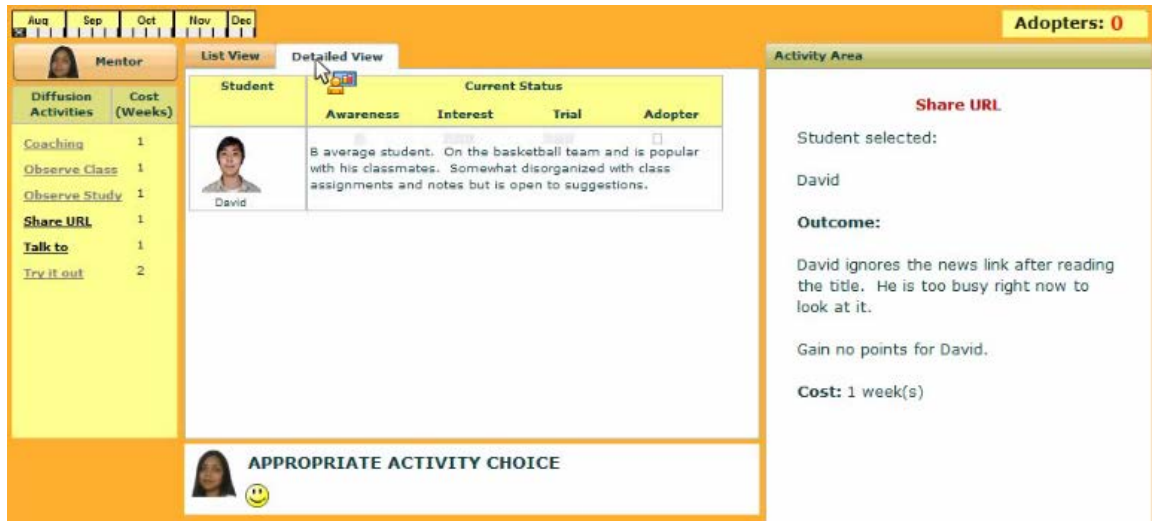


Figure 73. Screenshot Round 3, Level 1, Objective 1; Activity Log

Figure 73 illustrates the Activity Log as it appeared after the player used the “Share URL” activity while David was in the Awareness Phase. Because “Share URL” provides information about the innovation, the activity is appropriate and a smiley face is displayed in the Activity Log. Note that, despite the activity being appropriate, the outcome was ineffective, resulting in no points for David.

Figure 74 illustrates the Activity Log as it appears after completing the entire first objective. As indicated by the happy faces, each of the six activity choices that were made was appropriate for the phase of adoption that David was in. This was always the case in the first objective because, as the worked-out example, players were not allowed to select inappropriate activities. An example where a red X appears in the Activity Log is available in 3.1.2.D.

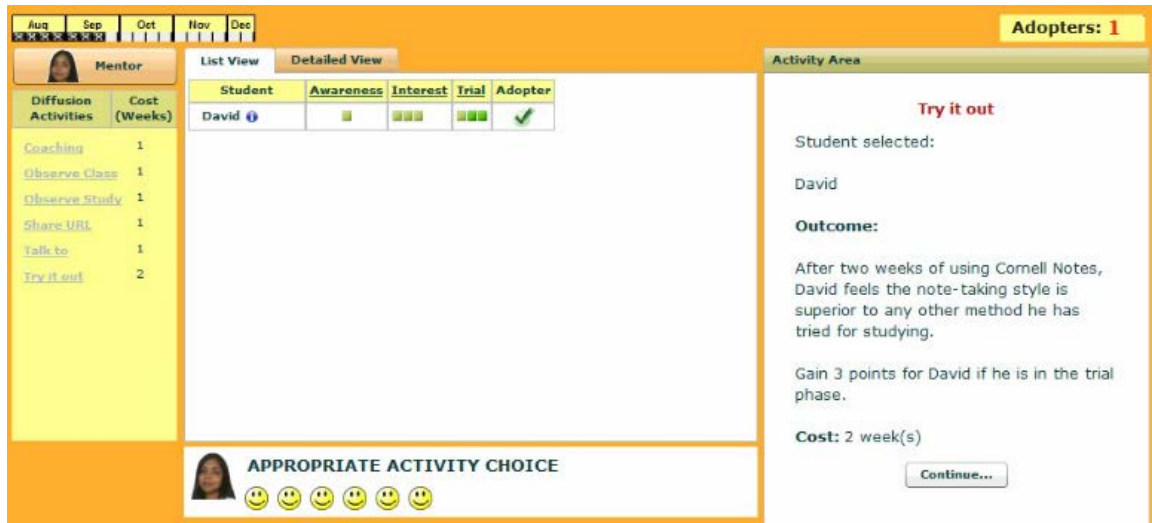


Figure 74. Screenshot Round 3, Level 1, Objective 1; Activity Log upon completing the objective

3.1.2 (Round 3, Level 1, Objective 2)

3.1.2.A

Once the player initially closes the Mentor Window in Objective 2, they are ready to begin the objective (Figure 75). Additional information was made available when the player moused-over the headings for the Awareness, Interest, and Trial phases in the same manner as the first objective of Round 3 (described in 3.1.1.D). Also note that the Sort Activities activity is provided to players as an option just as it was in Round 2 (2.1.1.B).

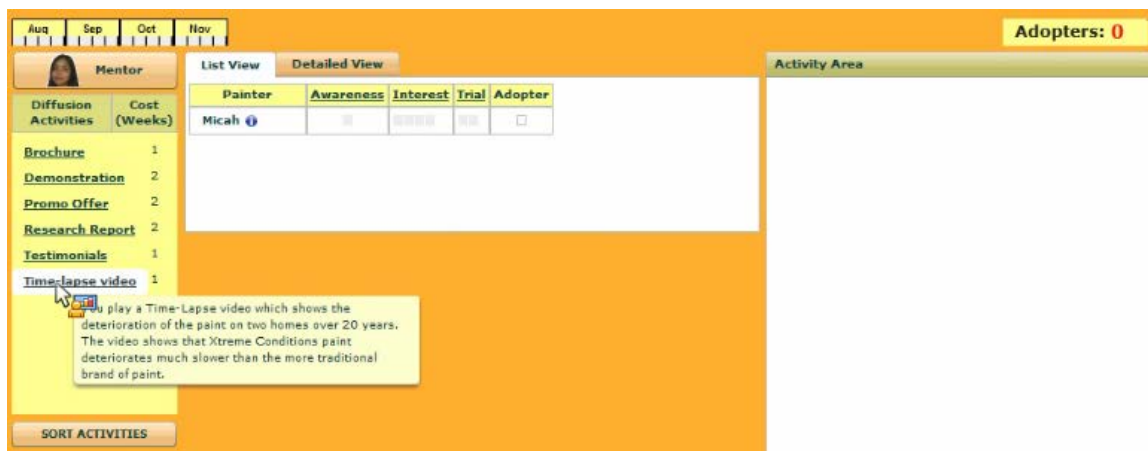


Figure 75. Screenshot Round 3, Level 1, Objective 2; Game screen

The feedback from Round 2 participants was generally positive about the Sort Activities activity. Participant 6 stated during their interview that “[The Sort Activities activity] was great. It was really useful because it kind of set my strategy for the rest of the objective and I was looking forward for it in the next objective and in fact I even wish it was in the first one.” Participant 7 thought the Sort Activities activity was a bit daunting because he was worried about being corrected by the mentor if he sorted any diffusion activities incorrectly. However, he then said that the “worst case scenario, in my opinion, is that nobody’s dying so if I put the brochure under the Trial, oh well. They don’t shoot me and drag my body to a line pit because I made some heinous error.” Interestingly, this participant made no mistakes while completing the Sort Activities activity.

3.1.2.B

During Round 2, the Probability Graph (described in 2.1.2) was not animated. It served only as a static chart to show the player the probability of getting an effective, somewhat effective, or ineffective result from using a particular activity for the current phase of adoption. During Round 2, Participant 7 stated that “I love the pie chart. Once I

learned how to use it, it was very, very helpful. I'm a visual learner... The colors are telling me what to choose, so why don't [I] do that?" Participant 6 stated that he "thought that was actually pretty cool. I understood it. As a gamer, I kinda liked it because the probability of you doing this yields such a result so you kind of weigh your options..." While Participant 6 and Participant 7 found the Probability Graph very useful, Participant 5 never understood the relationship between the colors on the graph and the probability of getting outcomes with varying amounts of effectiveness.

In Round 3, the Probability Graph was animated to increase player engagement, to make the element of randomness more evident, and to make the connection between outcomes and the Probability Graph more apparent. Because of this added functionality, the Probability Graph was henceforth referred to as the "Probability Spinner" in all subsequent rounds when discussing the game element with participants. Notice, in Figure 76, the only visual difference in the Probability Spinner and the previous Probability Graph is the blue line. In Round 3, when the player presses the "Continue" button to follow through with a selected activity, the color wheel spins while the blue line stays in place. The result of using the activity depends on what color is under the blue line when the color wheel stops spinning.

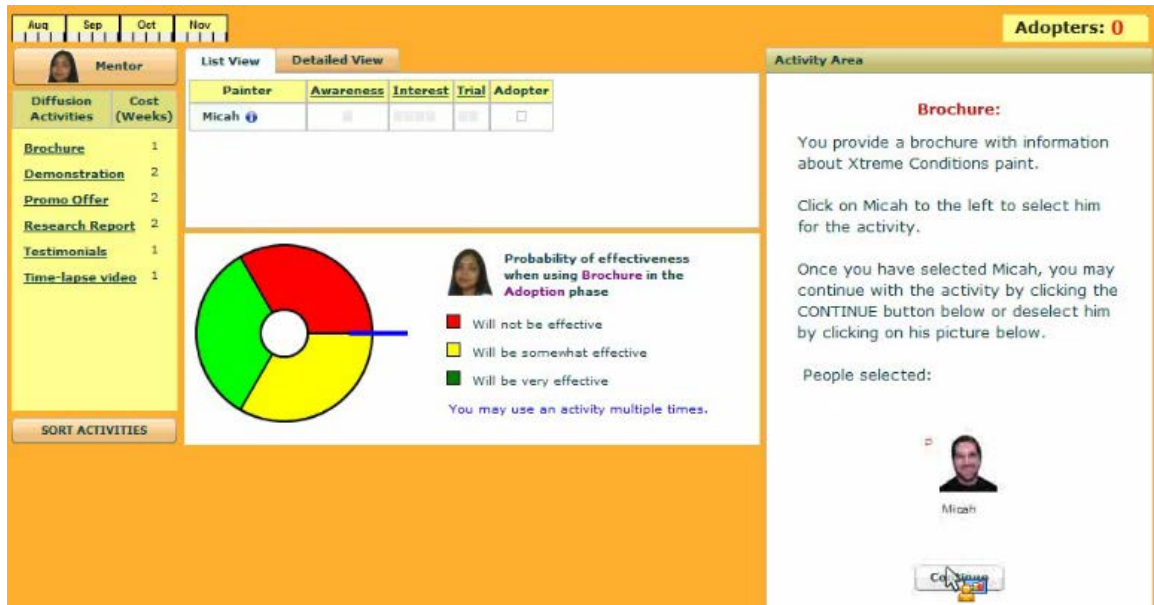


Figure 76. Screenshot Round 3, Level 1, Objective 2; Probability Spinner before the spin

Let's consider the example illustrated in Figure 76 through Figure 79. The player selected the "Brochure" activity which resulted in the appearance of the Probability Spinner and the mini-message that introduced it (described in 2.1.2.C). The Probability Spinner shows the player that using the Brochure while Micah is in the Awareness Phase has $\frac{1}{3}$ of a chance of not being effective (landing on red), $\frac{1}{3}$ of a chance of being somewhat effective (landing on yellow), and $\frac{1}{3}$ of a chance of being very effective (landing on green).

When the player pressed the "Continue" button, the color wheel spun and, in this case, landed on red (Figure 77). Because this was the first time during Objective 2 that the player used an activity (Brochure) that was appropriate for Micah's current phase of adoption (Awareness), the mini-message stating the stochastic nature of the game appeared (Figure 77).



Figure 77. Screenshot Round 3, Level 1, Objective 2; Mini-message to remind player that there is an element of chance in the outcomes of the game

After the player clicked the “OK” button (Figure 78), another mini-message was immediately given to remind the player that they “may, and sometimes will need to, repeat the same activity.” This message was added in Round 3 to give additional reinforcement to the player that repeating activities is an acceptable and sometimes worthwhile strategy.



Figure 78. Screenshot Round 3, Level 1, Objective 2; mini-message reminding the player that activities may be repeated

3.1.2.C

Once both mini-messages had been closed, the player could once again more clearly see where the Probability Spinner stopped spinning (Figure 79). In this case, the Probability Spinner stopped on red and then the corresponding outcome was displayed in the Activity Area. Notice that the effectiveness of the outcome is displayed in the Activity Area as well. Because the Probability Spinner landed on red, the text “Not Effective” appeared next to the Outcome label (also in red) and the outcome which resulted in no points was given. However, because the activity was appropriate, a happy face was added in the Activity Log.

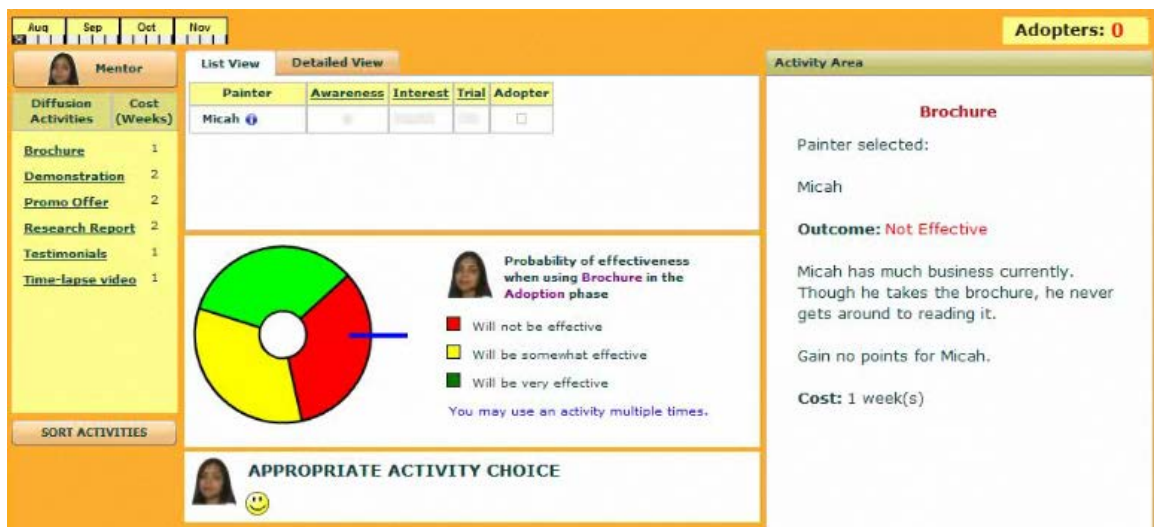


Figure 79. Screenshot Round 3, Level 1, Objective 2; Probability Spinner after the spin

3.1.2.D

Figure 80 illustrates another example of the Probability Spinner. In this case, the player used the Testimonials activity while Micah was in the Interest Phase. The Probability Spinner stopped on yellow yielding a “Somewhat Effective” outcome (also in yellow) which resulted in one adoption point for Micah. However, a red X appeared in the Activity Log to indicate to the player that, despite its effectiveness, the activity

(Testimonials) was not appropriate for Micah's current phase of adoption (Interest) because it did not provide Micah the opportunity to see the innovation in use.

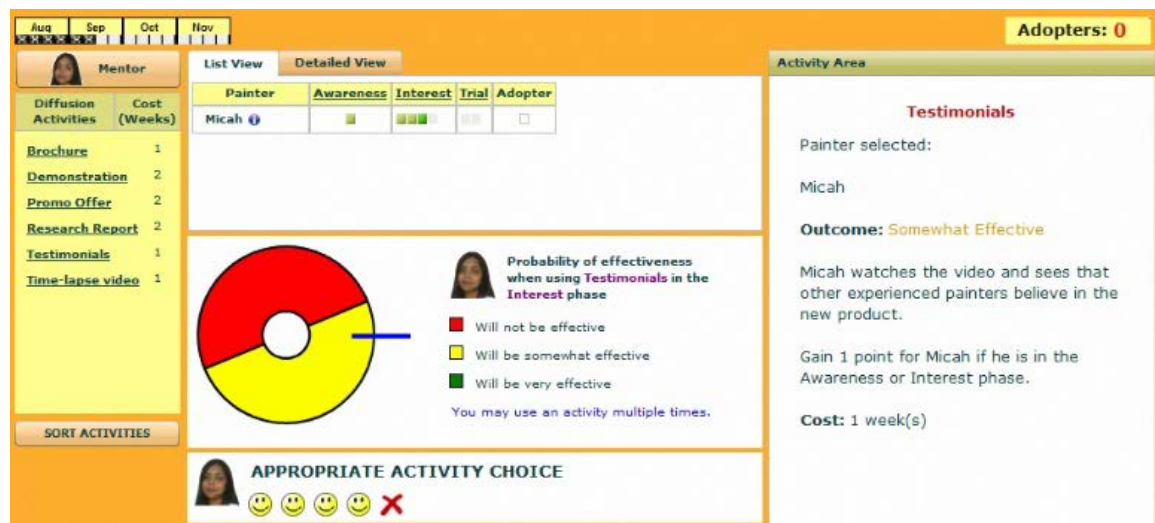


Figure 80. Screenshot Round 3, Level 1, Objective 2; Probability Spinner used with an inappropriate activity choice

3.1.3 (Round 3, Level 1, Objective 3)

3.1.3.A

In Round 3, an additional objective was added at the end of Level 1 so Objective 3 ceased to be the last objective of the level. Therefore, the instructional support was added into Objective 3 to be consistent with the 4C/ID Model which prescribes that the instructional supports be reduced gradually until the last objective of the level which provides the learner with no instructional support. In Round 3, Objective 3 had less instructional support than Objective 2 because it did not include the Probability Spinner and had fewer mini-messages providing guidance from the mentor. In addition, Objective 3 had more instructional support than Objective 4 because it included the Sort Activities activity and the Activity Log. Besides the addition of the Sort Activities

activity and the Activity Log, Objective 3 remained the same as it was in Round 2 (described in 2.1.3).

3.1.4 (*Round 3, Level 1, Objective 4*)

In Round 3, the first three objectives required the player to persuade a single individual to adopt an innovation. However, Objective 4, required the player to persuade multiple people to adopt an innovation.

Two primary reasons led to the addition of a fourth objective to Level 1. First, due to the amount of time that development of the game was taking and the number of iterative development cycles that had already taken place for the first level, staying within the timeline of the study was becoming a concern. The solution taken to address this issue was to add the fourth objective to help players learn to move multiple people through the phases of adoption instead of creating of an entire second level to achieve the same goal. Secondly, adding a fourth objective provided learners with needed additional practice in moving individuals through the phases of adoption before introducing them to new concepts.

3.1.4.A

Objective 4, as it existed in Round 3, required the player to “persuade the board members of Hoosier Sales Inc. to provide its sales representatives with a new rewards plan.” The objective description (Figure 81) informed the player of this objective and provided them with additional details about the rewards plan.

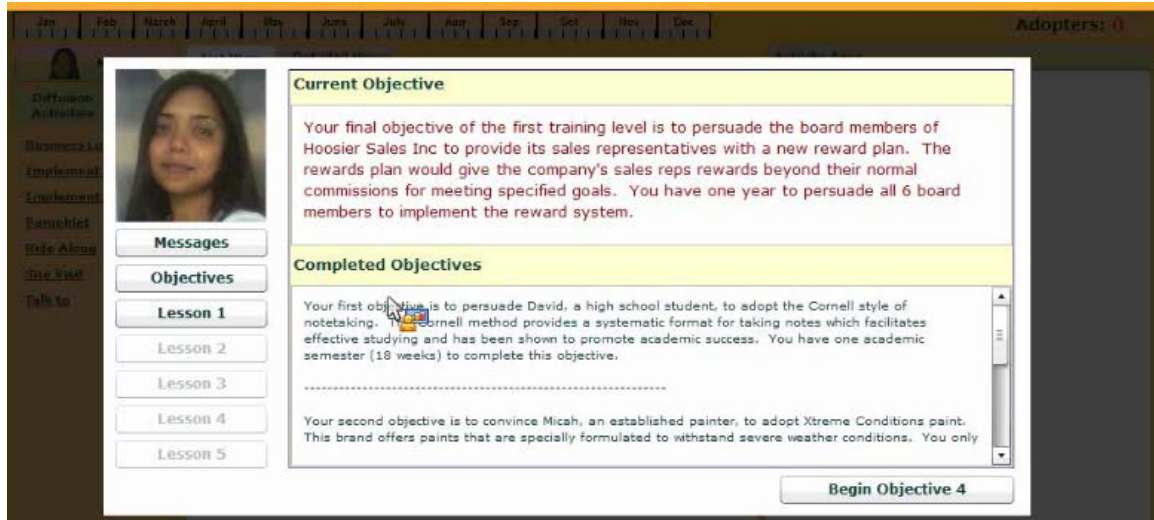


Figure 81. Screenshot Round 3, Level 1, Objective 4; Objective description

3.1.4.B

Unlike the previous objectives which involved convincing an individual to adopt an innovation, in Objective 4, the player is charged with persuading six people to adopt an innovation (Figure 82). Notice that there are several blue Personal Information icons which the player may use to view the information of each individual.

Jan		Feb	March	April	May	June	July	Aug	Sep	Oct	Nov	Dec
Mentor		List View Detailed View										
Diffusion Activities	Cost (Weeks)											
Business Lunch	1											
Implement A	5											
Implement B	6											
Pamphlet	1											
Ride Along	1											
Site Visit	2											
Talk to	1											

Board Member	Awareness	Interest	Trial	Adopter
Barbara	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Elizabeth	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Elliot	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Michael	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Ruth	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Theodore	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Figure 82. Screenshot Round 3, Level 1, Objective 4; Multiple individuals to persuade

3.1.4.C

Because there are multiple people, the player must target the number of people needed for each diffusion activity. The “Ride Along”, “Talk to”, and “Implement A” activities allow the player to select one individual in the same manner as the previous objectives. However, other activities required the selection of multiple people. For example, Business Lunch required the player to select three individuals to invite to the lunch (Figure 83). Similarly, the Site Visit required the player to select two individuals to involve in the activity.

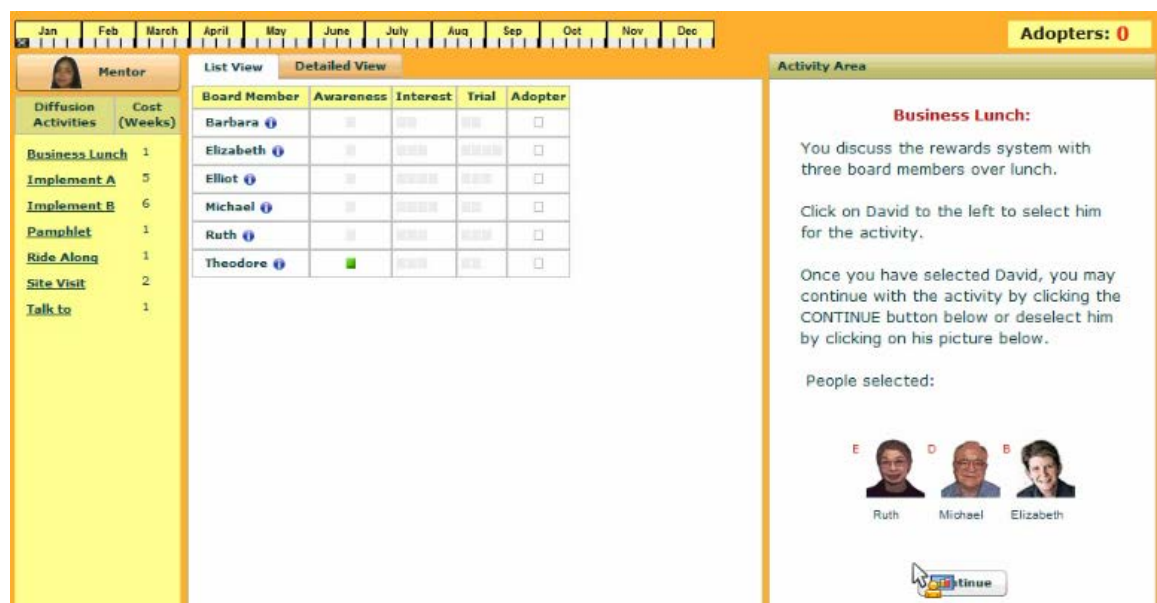


Figure 83. Screenshot Round 3, Level 1, Objective 4; Selecting multiple people

Other activities affected all six people and required no individual selection of people. For example, the Pamphlet activity involved distributing information to all six people but did not require the player to select any of them (Figure 84). The Implement B activity also affected all six people and did not require the player to select people individually.



Figure 84. Screenshot Round 3, Level 1, Objective 4; Selecting nobody

3.1.4.D

Though no additional Diffusion of Innovations concepts were introduced to the learner in Objective 4, the complexity of the objective did increase. For example, individuals were often in different phases of adoption (Figure 85). This required that players select activities appropriate for the phase of adoption of each of the individuals they intended to use in the activity. The designer hoped that the increase in complexity would be minor and not cause a significant increase in the learner's cognitive load.



Figure 85. Screenshot Round 3, Level 1, Objective 4; Individuals in different phases of adoption

Round 3 Findings

The three participants of Round 3 were the first to experience a version of Level 1 with four objectives. With the additional objective, the time Round 3 participants took to play through the Level 1 increased, ranging from 34 to 62 minutes.

The pre- and post-test scores for each Round 3 participant are provided in Table 12 along with the adjusted scores. As with all participants in the study, the maximum score on the pre- and post-test was 6 points. Because Round 3 participants played through only the first level and were only expected to learn about Adoption Phases, the adjusted score was calculated based on the top row of the grading rubric and so again had a maximum value of 2 points.

Table 12:

Round 3 Scores of Pre-/Post-tests

Participant	Pre-test	Post-test	Improvement	Adjusted Pre-test	Adjusted Post-test	Adjusted Improvement
8	0	2	2	0	2	2
9	0	2	2	0	2	2
10	0	2	2	0	2	2

For all three Round 3 participants, no points were given in the pre- or post-test for the portions of the rubric (rows 2 and 3) which tested concepts not introduced in the version of the game that was played. Because points were only awarded in the portion of the rubric (row 1) which tested the concepts that were introduced in the version of the game that was played, the pre- and post-test scores are the same as the adjusted pre- and post-test scores. The mean post-test score of 33% (2 out of 6 possible) was a 33% improvement over the mean pre-test score of 0%. The mean adjusted post-test score of 100% (2 out of 2 possible) was a 100% improvement over the mean adjusted pre-test score of 0%.

The 100% improvement from the mean adjusted pre-test score and the mean adjusted post-test score provided some evidence that the Round 3 version of Level 1 adequately prepared the participants to apply the innovation diffusion concepts they learned to the situation provided in the post-test. These results, along with qualitative data from the gameplay sessions and interviews, gave justification to begin development of the second level. Still, from issues that were revealed in the gameplay and interviews of this and future rounds, changes to the first level continued throughout the study.

The issues that were identified through the gameplay sessions and interviews of Round 3 participants were recorded along with solutions that were subsequently implemented in the same manner as previous rounds. Solutions to the most significant issues which interfered with the intended learning from DSG gameplay were implemented in Round 4. Therefore, the remaining findings of Round 3 are discussed in the following sections which also describe the version of the re-designed DSG which was developed and used in Round 4.

Chapter 8: Design Case Round 4

In Round 4, the re-designed DSG consisted of two levels. The first level had four objectives. The second level had two objectives.

4.1 (*Round 4, Level 1*)

The first three objectives of Level 1 in Round 4 were slightly modified versions of the first three objectives of Level 1 in Round 3. A new fourth objective (which involved persuading a single individual to adopt an innovation) was developed in Round 4 to replace the fourth objective of Round 3 (which involved diffusing an innovation throughout the entire group).

4.1.1 (*Round 4, Level 1, Objective 1*)

In Round 4, the first objective remained almost the same as it was in Round 3 (3.1.1). The few improvements made included changing the format of the “Completed Objectives” and adding a “KEY INFORMATION” button to allow the player to easily access the most pertinent information needed to complete the objectives of the level.

4.1.1.A

The initial message and the current objective remained the same in the first objective as it existed in the previous Round 3. However, the “Completed Objectives” were displayed in a different format to be more visually appealing to the player and to give them an understanding of how far through the game they have progressed (Figure 86). Beginning in Round 4, this format was used for all subsequent objectives in the game as well.

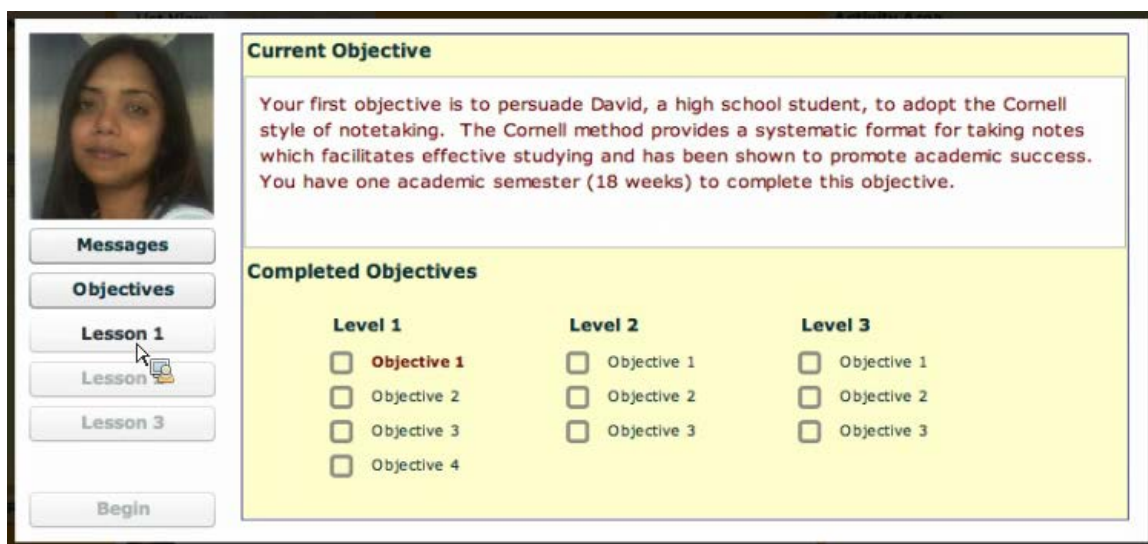


Figure 86. Screenshot Round 4, Level 1, Objective 1; Completed objectives

Notice the buttons in Figure 86 as well. To reflect the reduction of levels in the overall design of the game, the Lesson 4 and Lesson 5 buttons were removed. Also, the “Return to Game” button was renamed as the “Begin” button due to the confusion players had in seeing the “Return to Game” button prior to having ever seen the game. Once players had started the game and returned to the Mentor Window, the button label was updated to say “Return to Game”.

4.1.1.B

Just as most of the Round 1 and Round 2 participants thought the video was useful, at least one of the Round 3 participants found the video (which had been shortened in content and length) to be useful. Participant 8 said “I really like the video because it provided a good overview and because it was available for every [objective] so it was easy to go back and review any of the [information] that might have been missed.” Despite this remark, most participants in the entire study (including Participant 8) never returned to watch any of the instructional videos again. While Participant 9 did not make any comment about the video, Participant 10 felt the video could have been even more

concise. They noted in their interview responses that they “did not need to know the creator of the theory; that could have been taken out of the video.”

4.1.1.C

The most significant improvement to the first level in Round 4 was the addition of the “KEY INFORMATION” button which allowed the players to quickly view the mental map for the level (Figure 87). Though players had access to this information in Round 3 via the Lesson 1 video, the information was more difficult to access because it required that the player open the Mentor Window, click on the Lesson 1 video, and then move to the end of the video to view the information. Of all 20 participants who played the various versions of the DSG, none of them reviewed information that had been provided in the instructional videos after having watched it the first time.

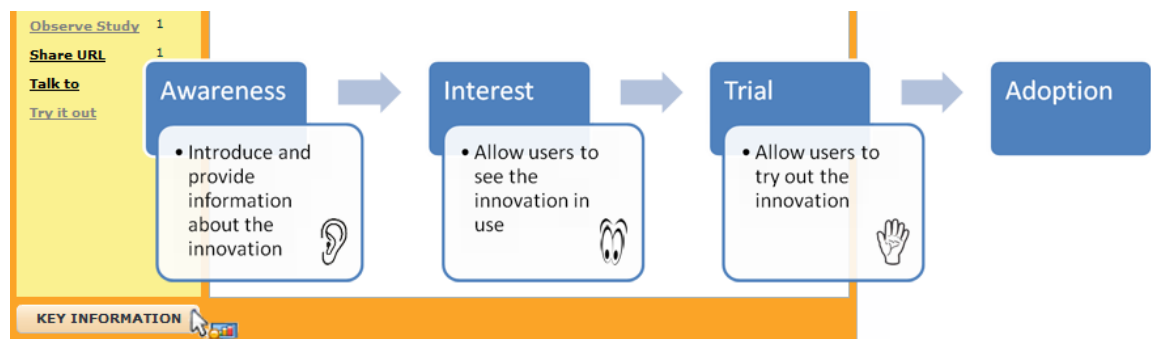


Figure 87. Screenshot Round 4, Level 1, Objective 1; KEY INFORMATION button and emphasizing selected activity via blue text

4.1.1.D

Another issue revealed in Round 3 was that some players would forget which activity they had selected while deciding which individuals to select, despite the activity being displayed in the Activity Area. To address this issue in Round 4, the currently selected activity was displayed in blue font in the diffusion activities list (Figure 88).

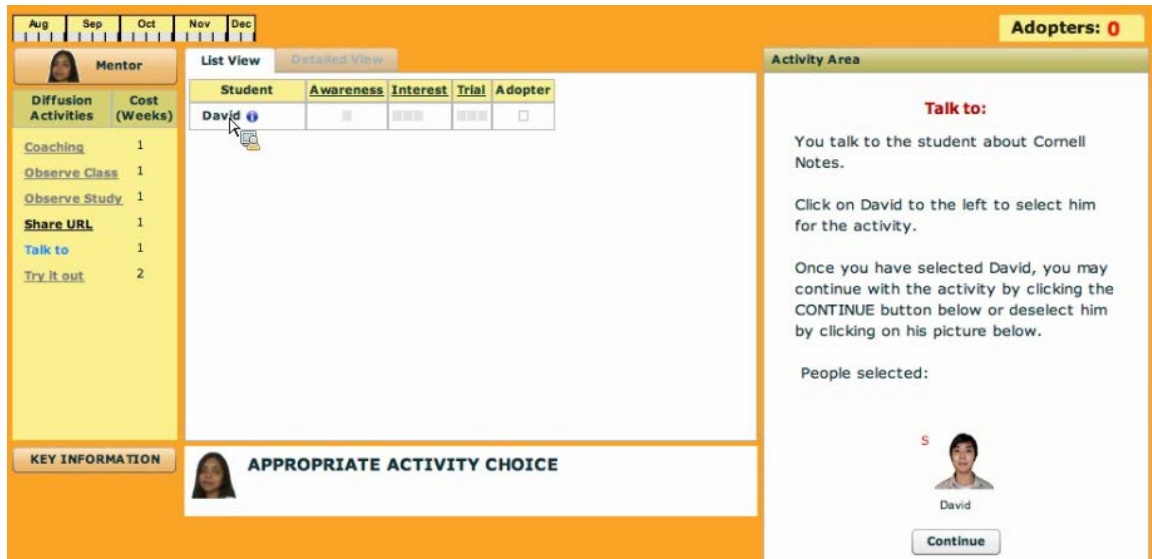


Figure 88. Screenshot Round 4, Level 1, Objective 1; Emphasizing selected activity via blue text

4.1.2 (Round 4, Level 1, Objective 2)

The second objective also remained almost the same in Round 4 as it existed in Round 3 (3.1.2). The changes that were made are described below in sections 4.1.2.A through 4.1.2.C.

4.1.2.A

In Objective 2 of Round 4, the “Completed Objectives” were displayed in the same manner as in Objective 1 of Round 4 (Figure 89). In the list of “Completed Objectives”, those which were actually completed have a green check and are underlined to indicate to the player that they may mouse-over the link to read about the previously completed activity. The current objective is shown in red to indicate to the player which objective they are currently on.

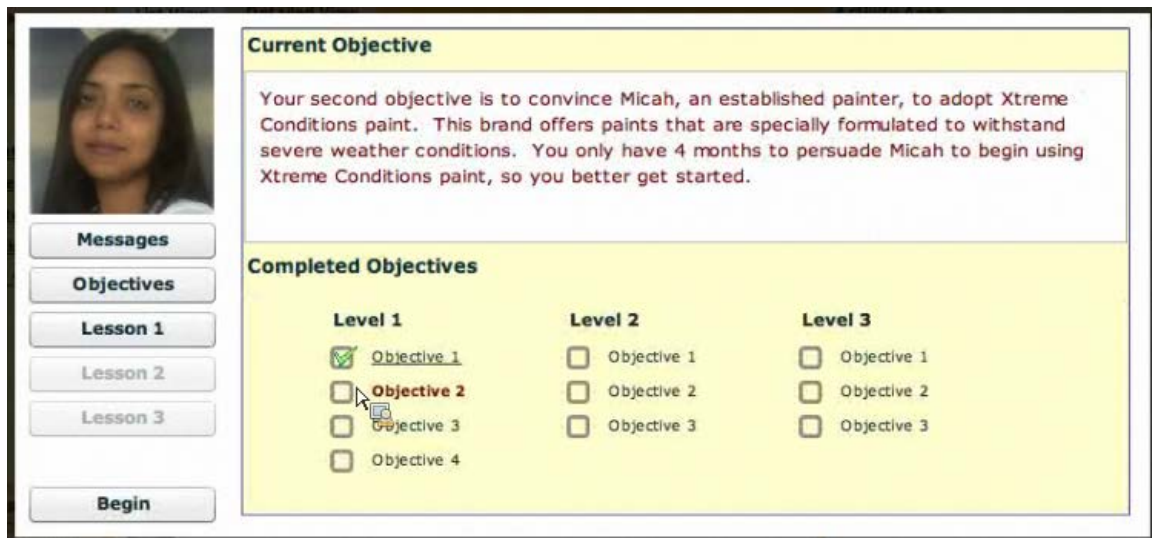


Figure 89. Screenshot Round 4, Level 1, Objective 2; Objectives

4.1.2.B

The “KEY INFORMATION” button which was introduced in Round 4 for the first objective was also added to Objective 2. This button allowed players to view the supportive information for the level without having to return to the instructional video (see 4.1.1.C).

4.1.2.C

In Round 4, the second objective of Level 1 still included the Sort Activities activity as an option for the player which would later be forced on the player if they made three errors in selecting activities appropriate in Objective 2 (see 2.1.2.G). However, the activity itself which was described in sections 2.1.2.H through 2.1.2.J was modified for Round 4 in two ways (Figure 90).

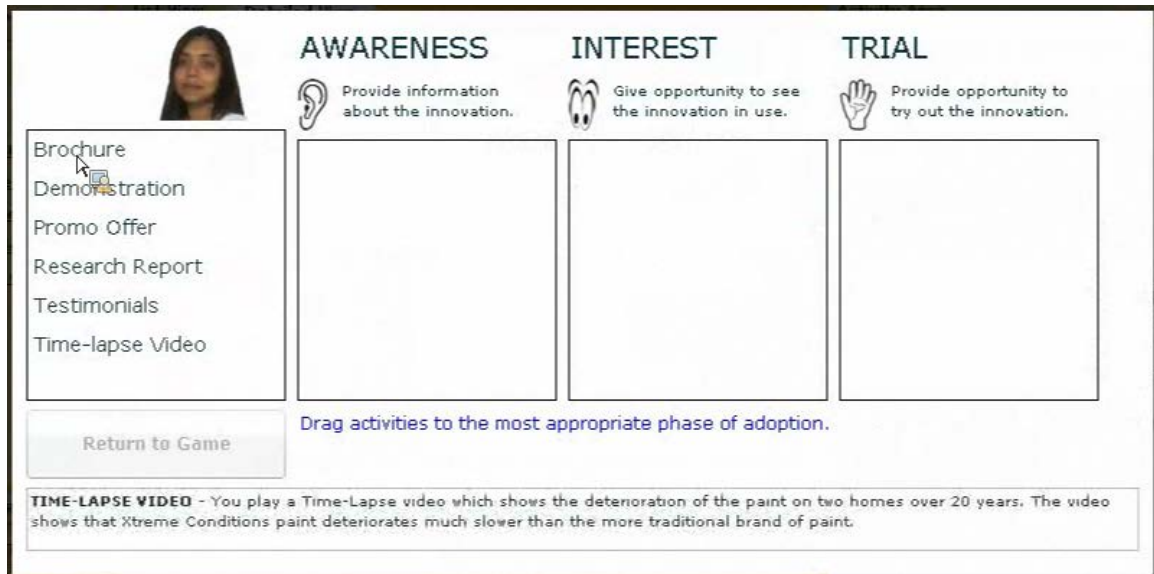


Figure 90. Screenshot Round 4, Level 1, Objective 2; Sort Activities activity

First, the player no longer had to click on a “View Activity Descriptions” button to view the descriptions of each activity as described in 2.1.2.I. Requiring players to open a new window on top of the Sort Activities activity to review the activity descriptions caused an unnecessary cognitive load on the player. In Round 4, the activity was changed so that the appropriate activity description would appear at the bottom of the sort window when the player moved their mouse over an activity (Figure 90). The second change to the Sort Activity is described in the next section (4.1.2.D).

4.1.2.D

The need to focus players’ attention on key information became evident in this round. Often players did not notice information that was being provided or simply chose to ignore it. In response to observing this phenomenon, interview questions were included to inquire as to what information players attended to and what information was unnoticed or ignored. To highlight the information that was not being attended to, a variety of solutions were implemented after Round 4. These solutions included appropriately timed mini-messages, highlighting and formatting of fonts to draw

attention, and the use of images intended to provide meaning instead of relying solely on textual information.

The Sort Activities activity was one element in which visuals were added to draw the player's attention to the defining attributes of each Adoption Phase (Figure 90). The image of the ear was intended to help the player understand that activities which allow people to "hear" about the innovation are appropriate for those individuals in the Awareness Phase. The image of the eyes was intended to help players understand that activities which allow people to "see" the innovation in use are appropriate for those individuals in the Interest Phase. The image of the hand was intended to help players understand that activities which allow players to try out the innovation in a "hands-on" manner are appropriate for those individuals in the Trial Phase.

These same images were included in the mental map which appeared in the instructional video and in the "KEY INFORMATION" button (see 4.1.1.C). In all cases, these images were added to address an issue which was revealed in previous rounds of the study. Specifically, players were relying on their own understanding of what was useful for raising awareness and interest based on their prior experiences.

4.1.2.E

Figure 91 illustrates a bug that appeared in Round 4 which caused the Probability Spinner to render the colors for the selected activity incorrectly.

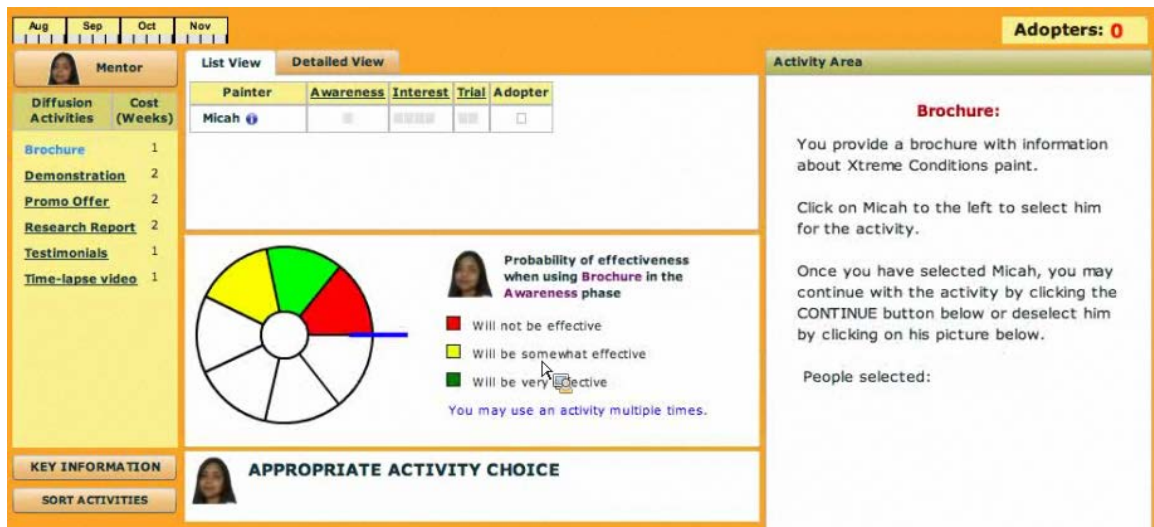


Figure 91. Screenshot Round 4, Level 1, Objective 2; Probability Spinner colors rendered incorrectly

This bug is provided here as an example of one of the many bugs revealed throughout the study. In cases such as this where the bug was distracting and/or hindered learning, the game session was interrupted and the issue was explained to the player so that they may progress with the game. This particular bug was inconsistent and at times the colors on the Probability Spinner were rendered correctly (Figure 92).

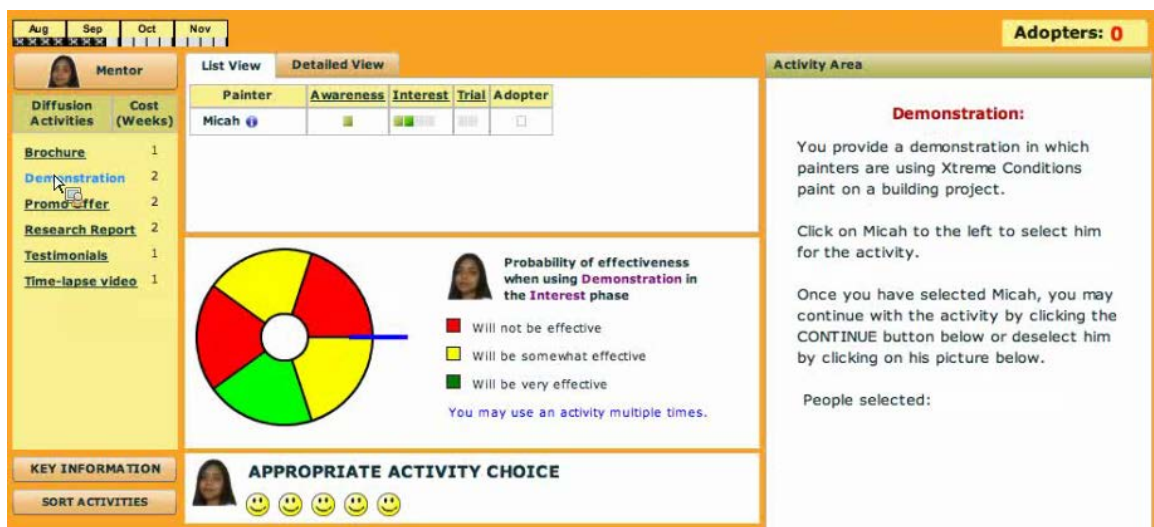


Figure 92. Screenshot Round 4, Level 1, Objective 2; Probability Spinner colors rendered correctly

4.1.2.F

The general impression of the gameplay by Round 3 participants was positive. Participant 9 said “I actually think it’s pretty cool. I think it’s a neat approach to demonstrating a topic or involving someone. It’s definitely more engaging than reading a textbook; either online or in hardcopy format.” However, the participants in Round 3 and prior rounds also noted that the game would have been more appealing if it had animation. Many of the participants seemed to believe that digital games are more fun if they include animation. For example, Participant 8 noted that while the scenarios for each objective were appealing because they were realistic, the lack of action and animation was unappealing.

The appeal of animated objects in the game was evidenced by participants’ reaction to the animated Probability Spinner which was introduced in Round 3. For instance, Participant 9 said they liked the spinner because it draws you in. Though participant 8 and 10 did not make a comment about the appeal of the Probability Spinner (likely due to the bug described in Section 4.1.2.D), participants in subsequent rounds who interacted with the Probability Spinner after the bug was fixed appreciated that it was animated, noting that the Probability Spinner was appealing and increased engagement.

4.1.3 *(Round 4, Level 1, Objective 3)*

As with the first two objectives of Level 1, few changes were made to the third objective as it existed in Round 3 (see 3.1.3). The changes that were made are described below in sections 4.1.2A through 4.1.2.C.

4.1.3.A

The screenshot of the third objective of Level 1 (Figure 93) shows that the objective was largely unchanged in Round 4. Just as with the previous version, the Probability Spinner was removed from the third objective as were the majority of the mini-messages. The most significant changes that were made included the “KEY INFORMATION” button (described in 4.1.1.C) and the Sort Activities activity (described in 4.1.2.C).

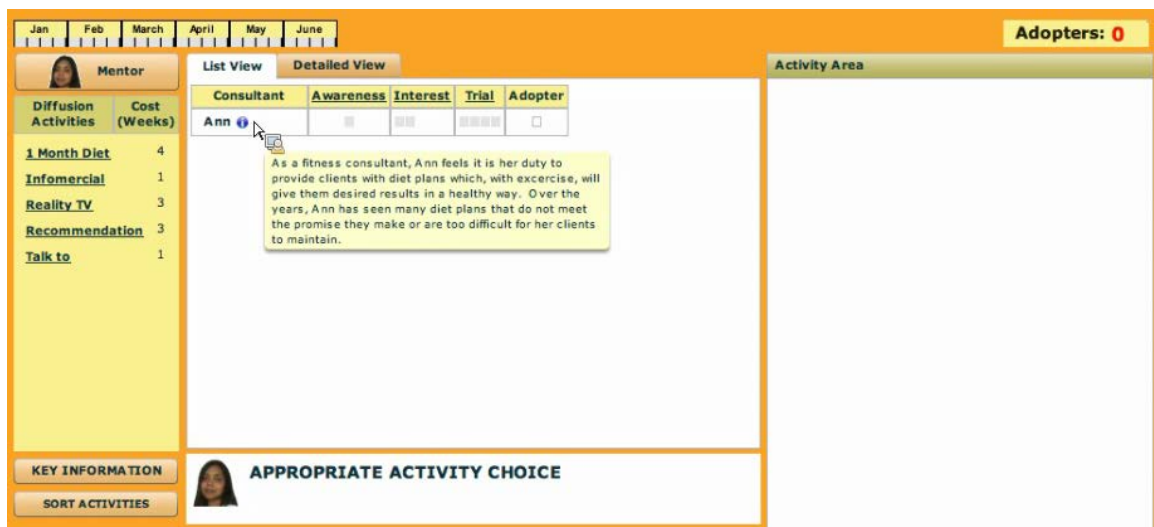


Figure 93. Screenshot Round 4, Level 1, Objective 3; Game screen

4.1.4 (Round 4, Level 1, Objective 4)

The fourth objective used in Round 4 was completely different than the fourth objective used in Round 3. During Round 3, the increase in complexity from expecting the player to persuade one individual in each of the first three objectives to expecting the player to persuade a group of individuals in the fourth objective was revealed as a hindrance to learning. For example, upon seeing the multi-person fourth objective, Participant 9 said “Well suddenly this looks overwhelming...” Simplifying the fourth round was also intended to reduce the time required to complete the first level which

increased dramatically in Round 3 with the inclusion of the multi-person objective.

Additionally, it became apparent to the designer that increasing the complexity within a level was not consistent with the 4C/ID Model which was guiding the re-design of the DSG. Therefore, this more complex objective was instead used in the second level and a new fourth objective was created for Level 1.

As the final objective of the first level, no instructional support was provided to the player in the new Objective 4. The objective includes very few mini-messages, none of which provide instruction about how to effectively apply the diffusion of innovations concepts. Additionally, this final Level 1 objective did not include instructional elements such as the Probability Spinner, the Activity Log, the Sort Activities activity, or the “KEY INFORMATION” button.

4.1.4.A

The initial message of the objective (Figure 94) made known to the player that they must complete this last objective of Level 1 with no instructional support.

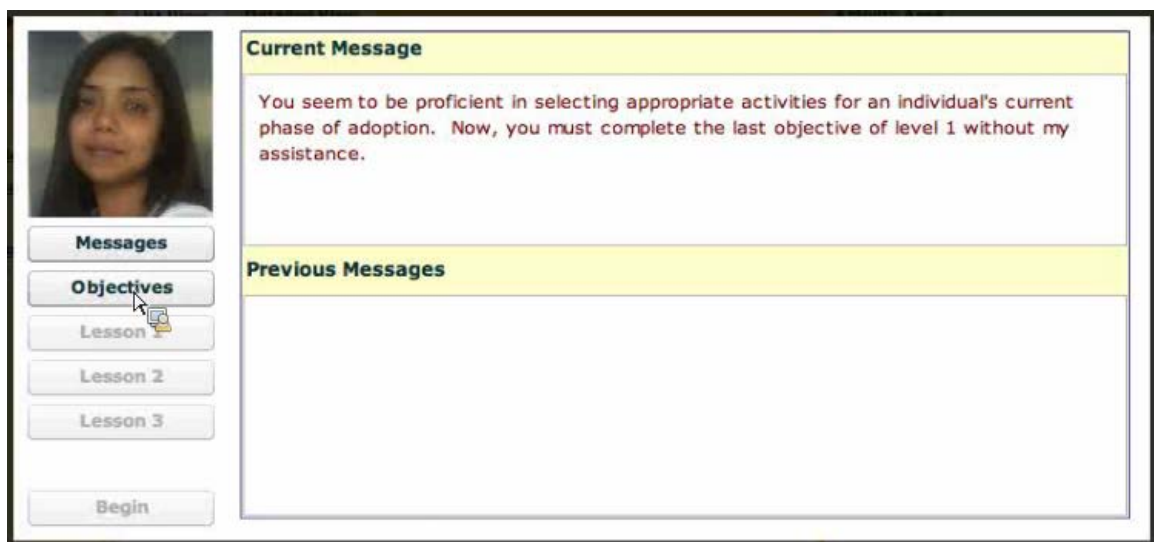


Figure 94. Screenshot Round 4, Level 1, Objective 4; Initial message

4.1.4.B

As with all objectives in the game, the player was provided with a short description of the objective and of the innovation which they would be persuading people to adopt (Figure 95). In this case, the player is only given eight game weeks to complete the objective.

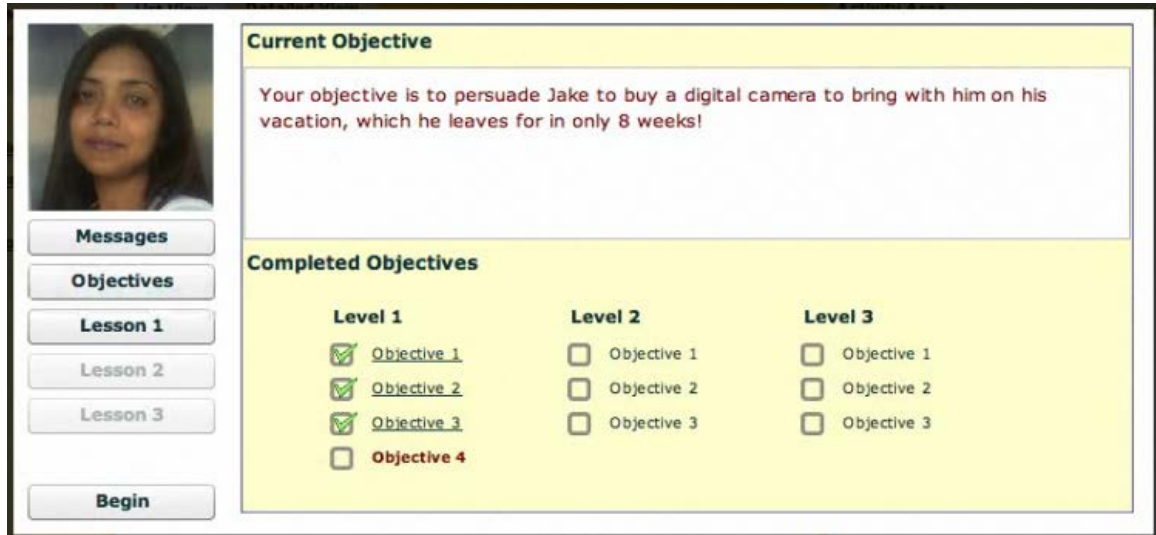


Figure 95. Screenshot Round 4, Level 1, Objective 4; Objectives

4.1.4.C

The screenshot of the new fourth objective (Figure 96) shows that the objective is very similar to the first three objectives the player completed in Level 1. The only difference in the fourth objective is that the instructional elements have been removed (as described in 4.1.4) and, as with each new objective, a new scenario is provided (new innovation, new individual to persuade with new personal characteristics, and new diffusion activities).



Figure 96. Screenshot Round 4, Level 1, Objective 4

4.1.4.D

The screenshot in Figure 97 gives an example of the player running out of time before completing the objective (Jake has not adopted the innovation and there are no more weeks remaining on the calendar). Throughout the entire study, the difficulty of each objective was adjusted to ensure it was challenging but not too difficult to complete. The level of difficulty was tweaked by modifying the number of weeks on the calendar, changing the number of required adoption points needed to move an individual through the phases of adoption, manipulating the ratio of effective and ineffective outcomes for a particular activity, and by changing the impact of each outcome.

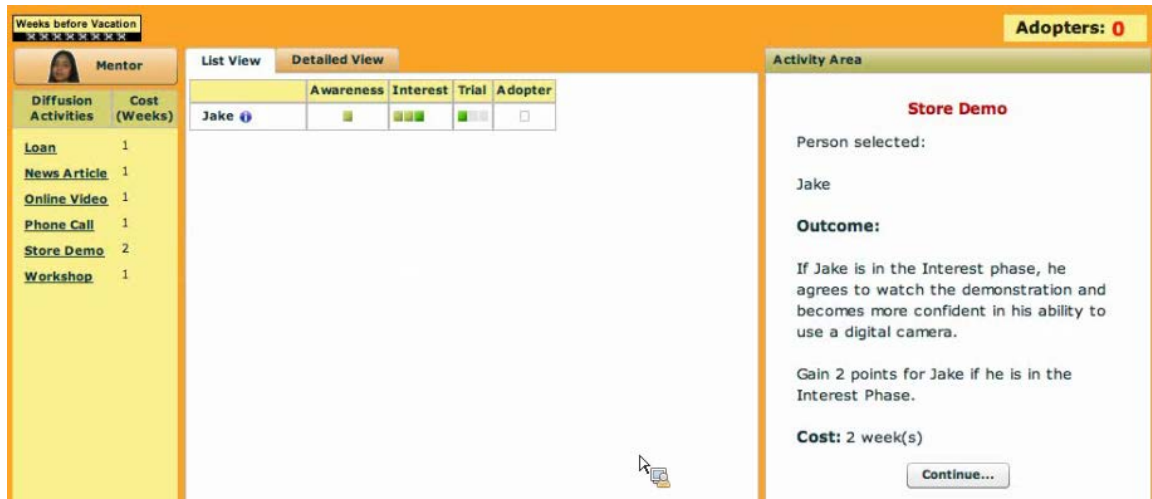


Figure 97. Screenshot Round 4, Level 1, Objective 4; Running out of time

4.2 (Round 4, Level 2)

Level 2 was first developed in Round 2 and initially consisted of two objectives which are described in 4.2.1 and 4.2.2 below. In Round 4, only two of the three planned objectives of Level 2 were developed. The first objective of Level 2 was developed by expanding on the objective that had previously been used in Round 3 as the fourth objective of Level 1. These objectives are described in more detail in the following sections (4.1.1 through 4.2.2).

4.2.1 (Round 4, Level 2, Objective 1)

The first objective of Level 2 was formerly the fourth objective of the Level 1. Therefore, Objective 1 was previously described in 3.1.4. In Round 4, modifications were made to include supportive information related to the new concept of Adopter Types that is introduced in Level 2. This supportive information is provided through an instructional video in the same manner the supportive information related to Adoption Phases was provided in Level 1.

4.2.1.A

Objective 1 of Level 2 begins with an introductory message (Figure 98) which tells the player they are moving on to the next level and will be learning “which types of people to work with to speed up the diffusion of an innovation.”

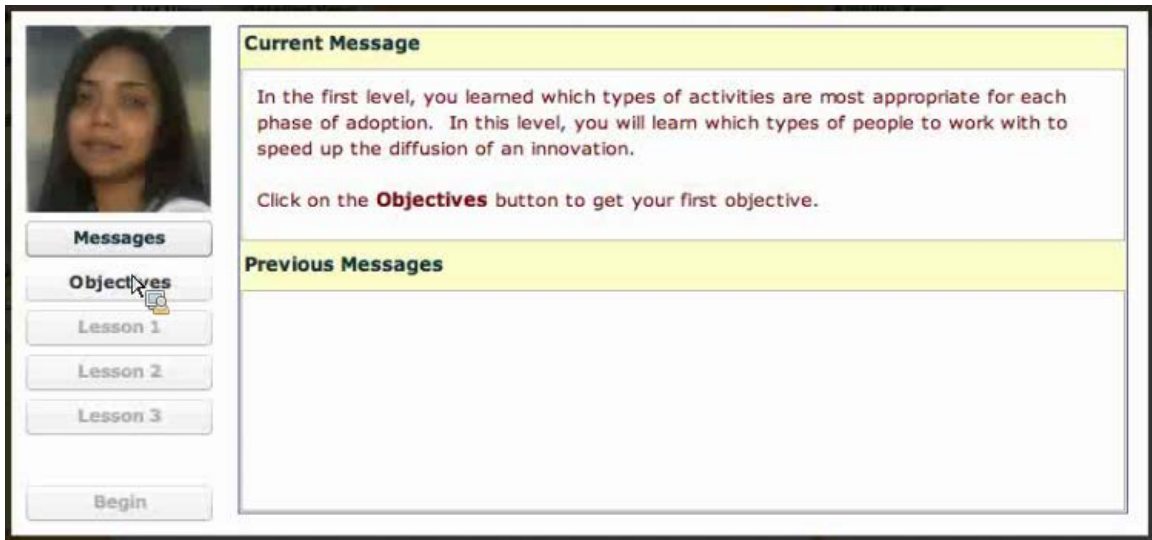


Figure 98. Screenshot Round 4, Level 2, Objective 1; Initial message

4.2.1.B

The objective description (Figure 99) gives the details of the first objective where the player must convince multiple people to adopt an innovation. In this case, the player must convince the Team Leaders of 6 sales teams to implement a new rewards plan.



Figure 99. Screenshot Round 4, Level 2, Objective 1; Objectives

4.2.1.C

For the first time in the game, the “Lesson 2” button is enabled after the player clicks on the “Objectives” button to allow players to watch the instructional video for Level 2 (Figure 100). To ensure the player watches the video to learn how to apply the concept of Adopter Types to more quickly diffuse an innovation throughout a group of people, the “Begin” button remains disabled until the player presses the “Play” button on the Lesson 2 video.

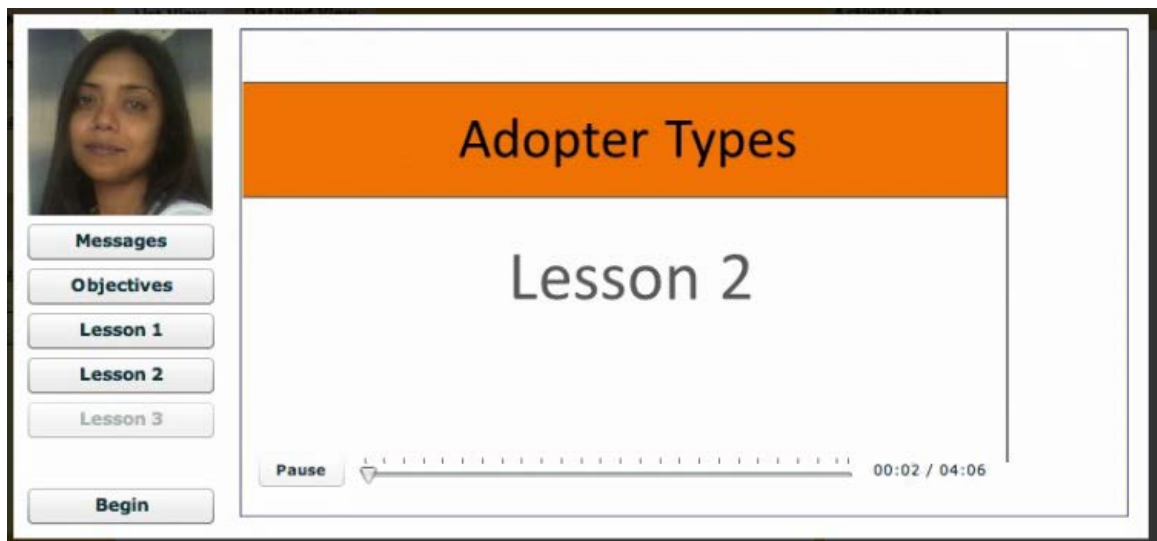


Figure 100. Screenshot Round 4, Level 2, Objective 1; Lesson 2 video

4.2.1.D

The Lesson 2 video begins by introducing the player to the five types of adopters; Innovators, Early Adopters, Early Majority, Late Majority, and Laggards (Figure 101). The blue faces were included to give the players a sense of how each Adopter Type feels about innovation. The Adopter Types that are further to the left have a higher degree of innovativeness and are more likely to be the first to adopt an innovation.

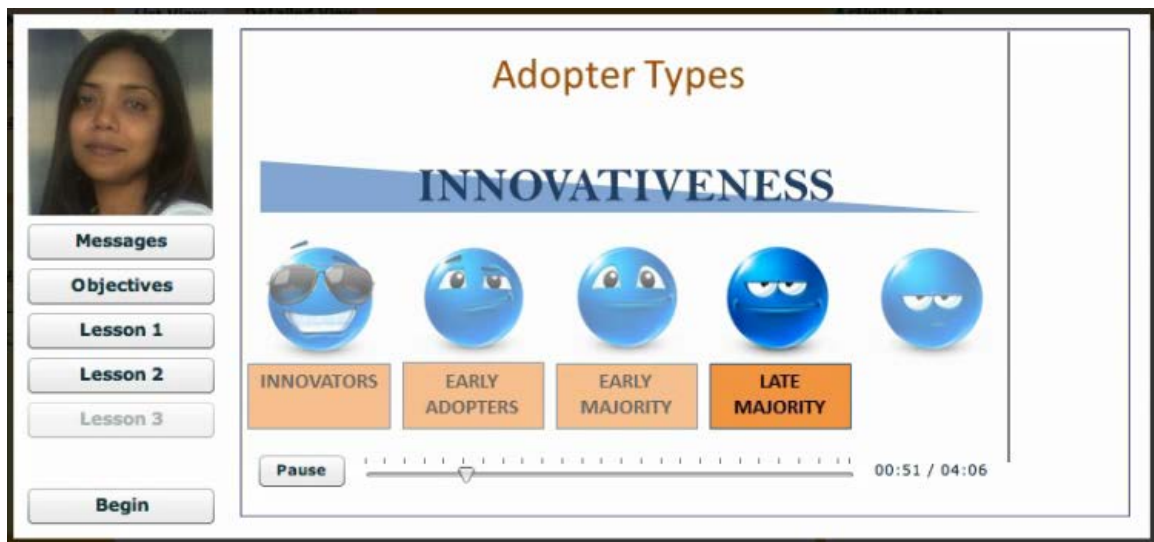


Figure 101. Screenshot Round 4, Level 2, Objective 1; Lesson 2 video (51'' mark)

4.2.1.E

The Lesson 2 instructional video goes on to tell the players what characteristics are common of individuals who belong to each Adopter Type and how many people generally fall into each Adopter Type category. In Figure 102, the video is currently showing the player that the Early Majority typically accounts for 34% of the entire population and that individuals who are in the Early Majority generally interact often with peers and follow the lead of Early Adopters.

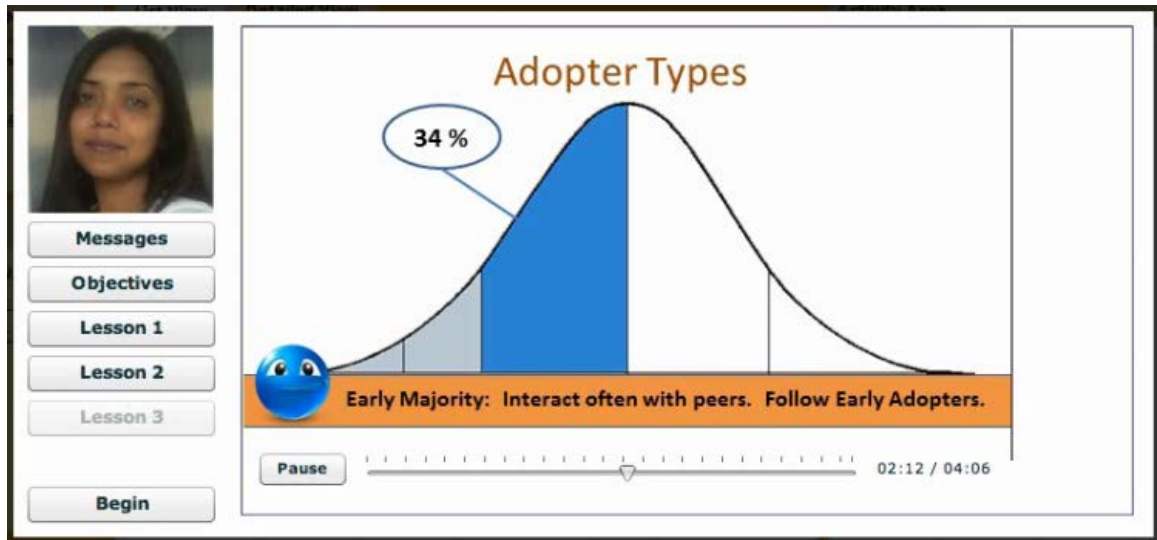


Figure 102. Screenshot Round 4, Level 2, Objective 1; Lesson 2 video (2' 12'' mark)

4.2.1.F

After the characteristics of each adopter type are discussed, the video continues by providing the players with a mental map that is needed to complete the objectives of Level 2. The Level 2 mental map (Figure 103) builds on the Level 1 mental map (4.1.1.C) by telling the players to focus on persuading the Early Adopters first. The video provides the justification for this approach, explaining that by persuading Early Adopters (those who are highly respected for their high success rate when adopting new innovations) the other members of the system will be more open to adopting the innovation.

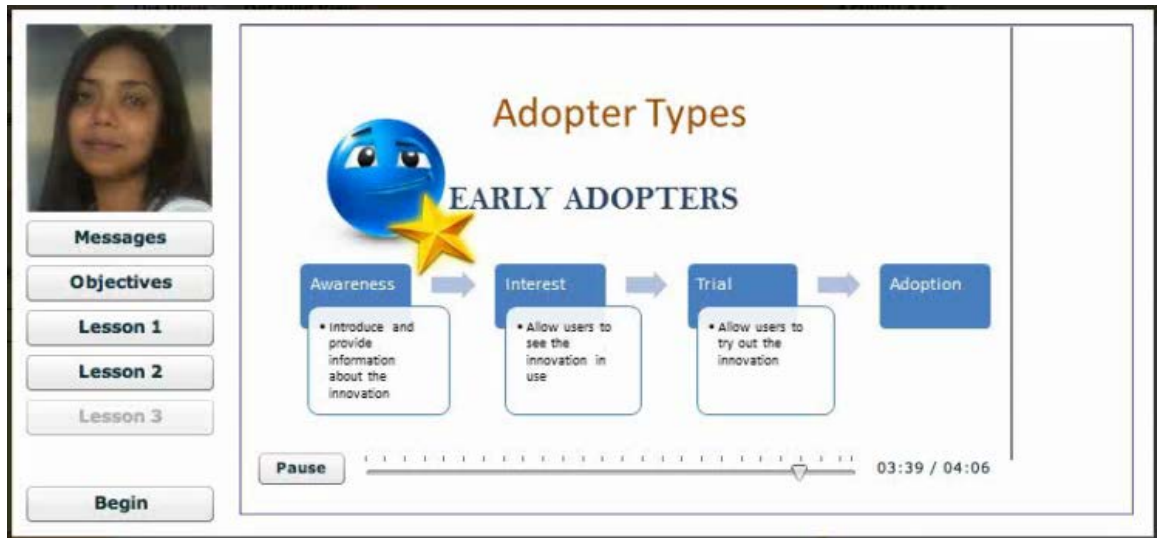


Figure 103. Screenshot Round 4, Level 2, Objective 1; Lesson 2 video (3' 39'' mark)

4.2.1.G

As players begin the objective, they are immediately provided with a mini-message introducing a new Information Activity called “Get Personal Info” (Figure 104).

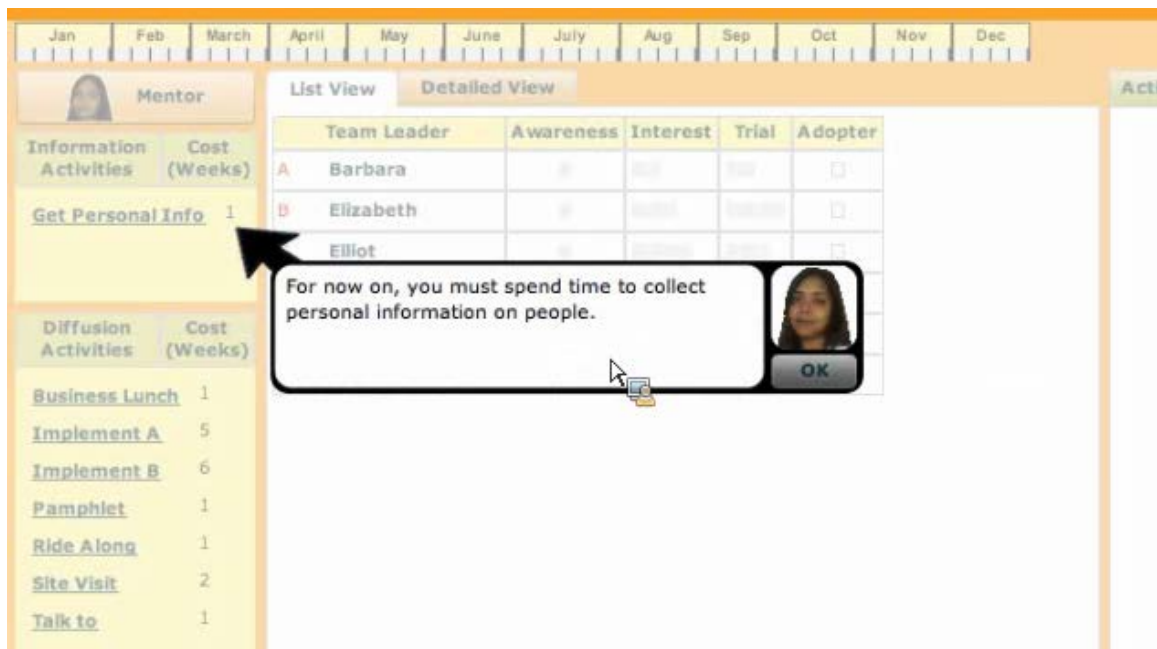


Figure 104. Screenshot Round 4, Level 2, Objective 1; Mini-message introducing the Get Personal Info activity

4.2.1.H

The “Get Personal Info” activity requires the player to spend a week to get the Personal Information of three people in the system. This is the first time that players in Round 4 are introduced to an activity which requires the selection of multiple individuals. Figure 105 shows the player selecting three individuals for the “Get Personal Info” activity.



Figure 105. Screenshot Round 4, Level 2, Objective 1; Using the Get Personal Info activity

4.2.1.I

Once the player has used the “Get Personal Info” activity, the blue information icon that was used in all previous objectives is displayed next to each of the individuals that were selected (Figure 106).

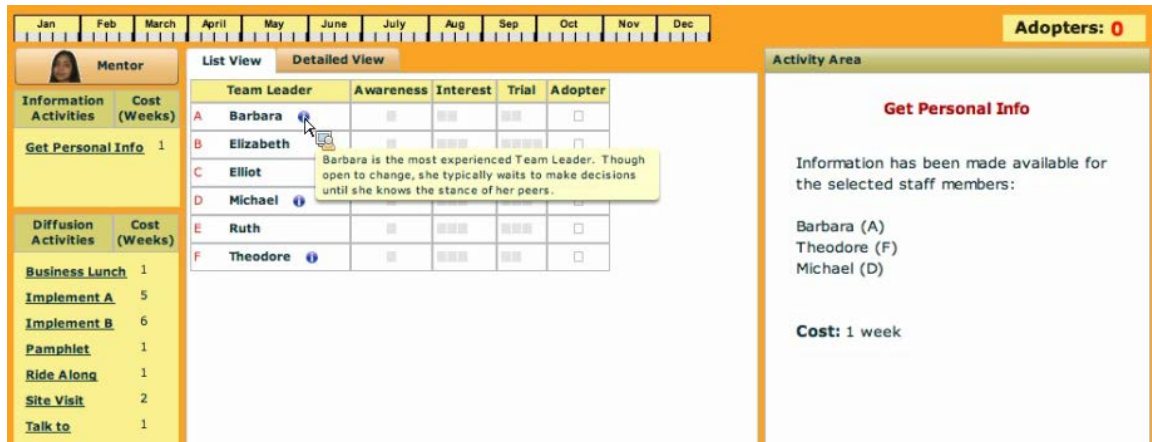


Figure 106. Screenshot Round 4, Level 2, Objective 1; Information icons

In the first objective of Level 2, players were not allowed to use any of the diffusion activities until they had gotten Personal Information on every person in the system. This approach of immediately getting to know the people in the system is considered to be an effective strategy for diffusing an innovation, particularly for a change agent who is not a member of the system.

4.2.1.J

Once information has been collected on all individuals in the system, the “SORT PEOPLE” button appears (Figure 107) along with a mini-message telling the player to “use this activity to identify the Adopter Type of each person.”



Figure 107. Screenshot Round 4, Level 2, Objective 1; Mini-message introducing the Sort People activity

4.2.1.K

As in the worked-out example of Level 2, the player is forced again forced to make proper decisions. They are first forced to get to know everybody by getting personal information on each person in the group. Then, they are forced to complete the Sort People activity (Figure 108). The Sort People activity works similarly to the Sort Activities activity used in Level 1. While the Sort Activities activity required players to identify the Adoption Phase that each activity is best suited for, the Sort People activity required players to identify the Adopter Type category that each individual belongs to.

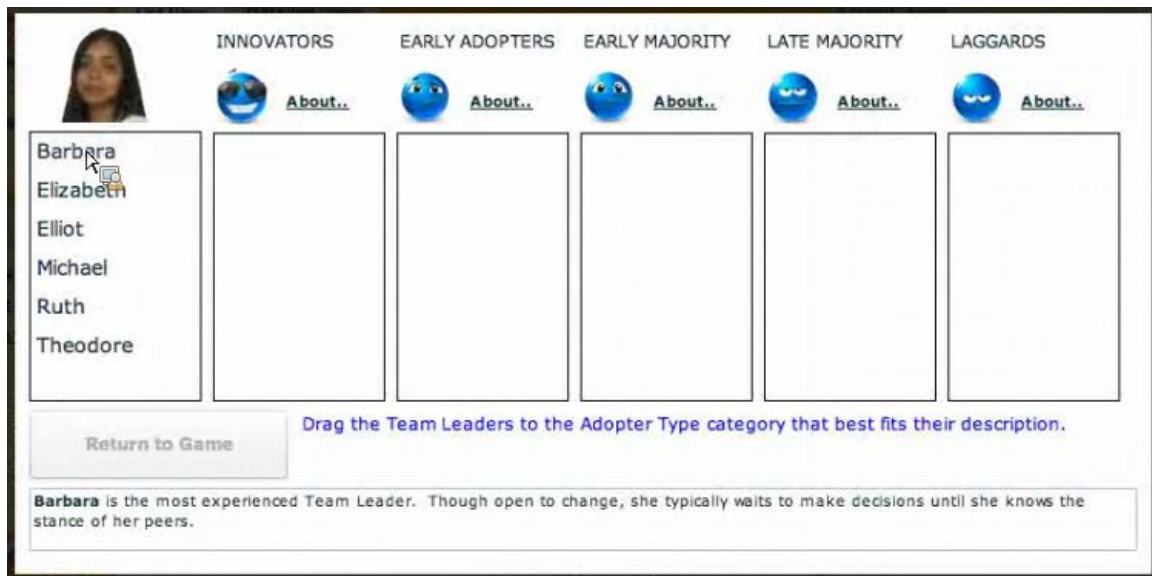


Figure 108. Screenshot Round 4, Level 2, Objective 1; Sort People activity

Similar to the Sort Activities activity, the Sort People activity allowed players to review the personal information of each person at the bottom of the sorting activity by moving their mouse over the person's name.

4.2.1.L

The blue faces which were used in the Lesson 2 instructional video are used in the Sort People activity to remind the players that each adopter type has different characteristics that make them more or less likely to adopt an innovation (Figure 109). Additionally, the "About.." links allow players to quickly review the common characteristics of each Adopter Type.

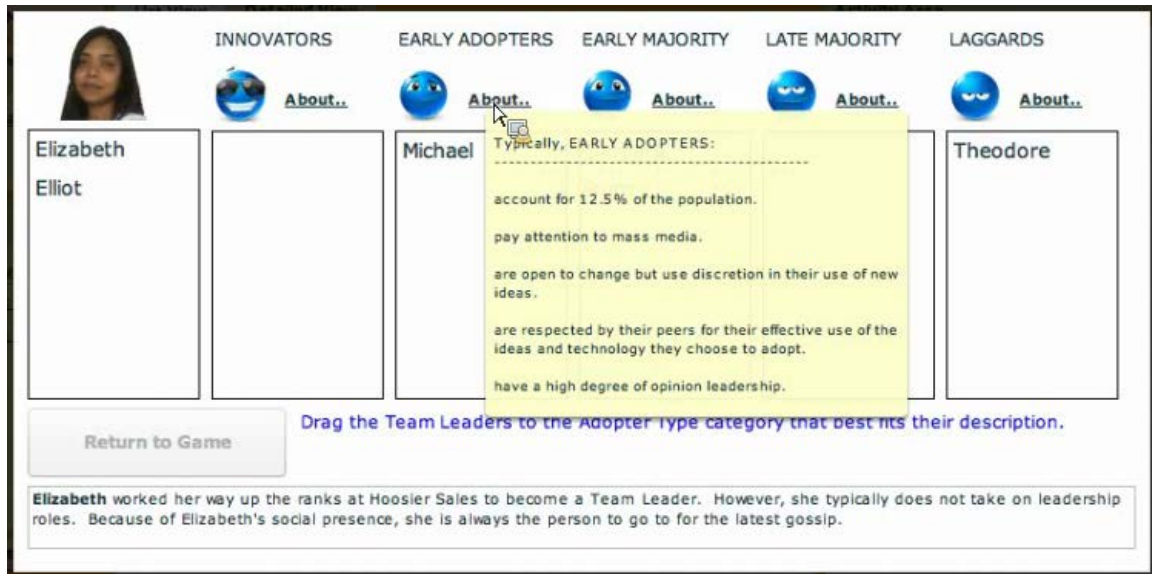


Figure 109. Screenshot Round 4, Level 2, Objective 1; “About..” links in Sort People activity

4.2.1.M

In the same manner as the Sort Activities activity, once the player has attempted to sort all the individuals (nobody remains in the far left column) in the Sort People activity, the number of incorrectly sorted people is provided (Figure 110).

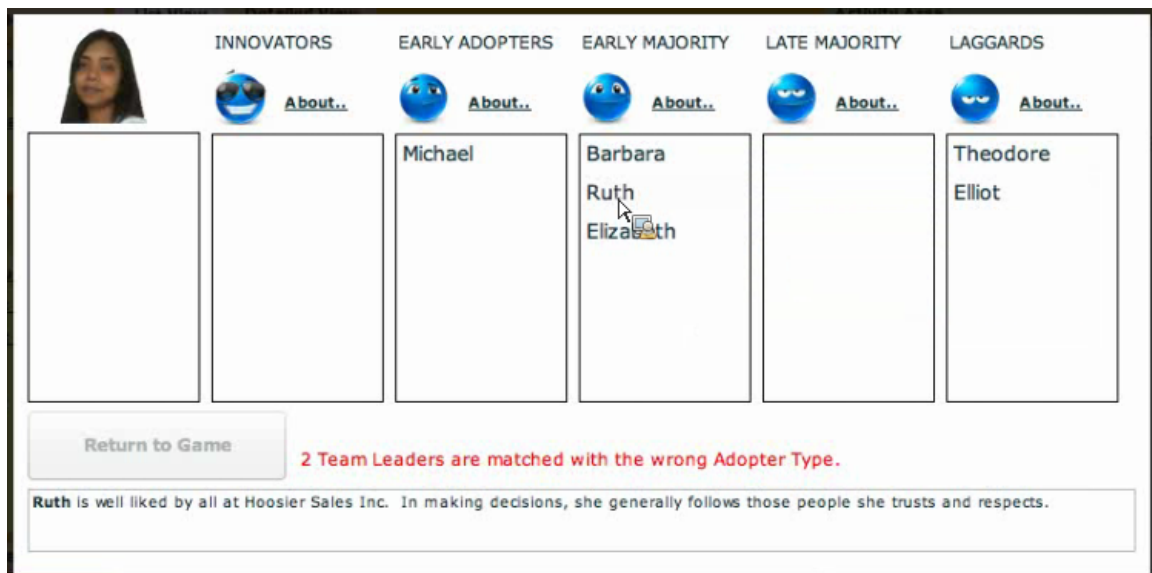


Figure 110. Screenshot Round 4, Level 2, Objective 1; Errors in Sort People activity

4.2.1.N

Players must correct their mistakes before the “Return to Game” button becomes enabled, allowing the player to return to the objective (Figure 111).

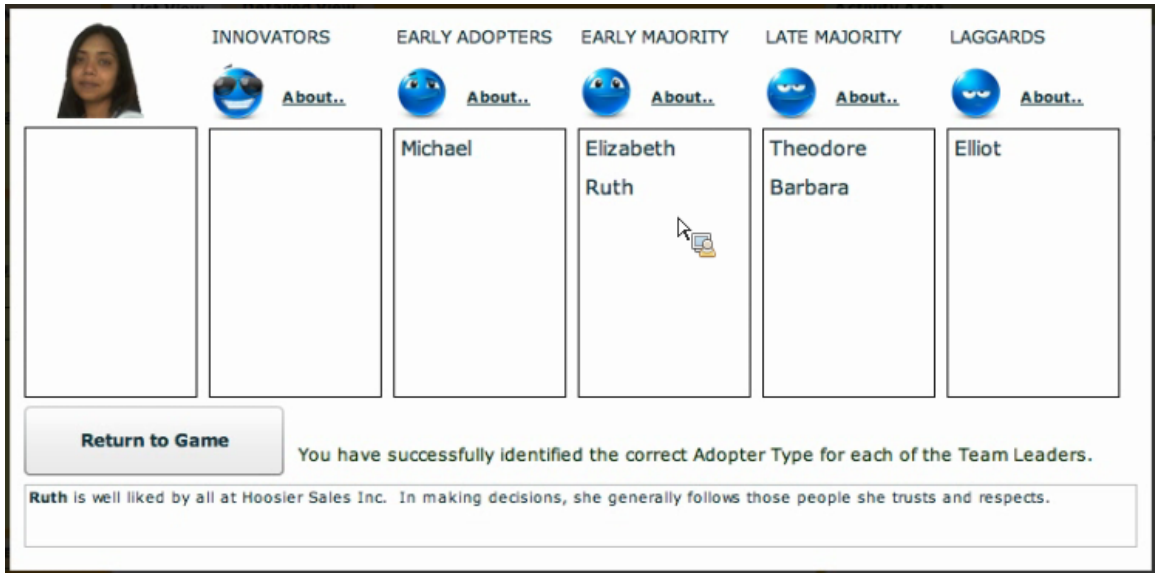


Figure 111. Screenshot Round 4, Level 2, Objective 1; Sort People activity completed

Upon returning to the game the “SORT PEOPLE” button is renamed to “REVIEW PEOPLE” (Figure 112) and a mini-message is provided to inform the player that they “may review the Team Leaders’ Adopter Type at any time.”

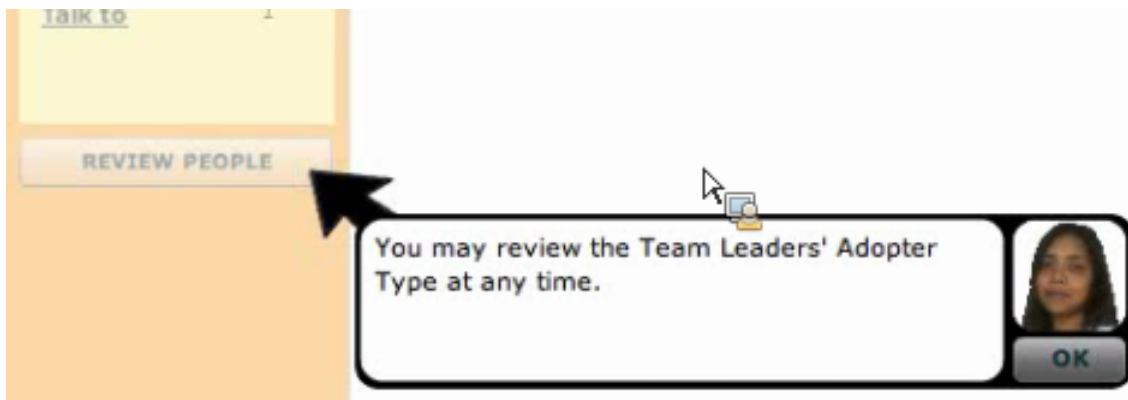


Figure 112. Screenshot Round 4, Level 2, Objective 1; Mini-message after completing the Sort People activity

4.2.1.O

One last mini-message is provided before the player can begin selecting diffusion activities (Figure 113). This message re-emphasizes the need to target the Early Adopter(s), Michael in this case, for diffusion activities so that their influence will speed up the spread of the innovation throughout the system.



Figure 113. Screenshot Round 4, Level 2, Objective 1; Mini-message to focus player's attention on Michael

4.2.1.P

After the player has successfully completed the Sort People activity, orange adopter type icons are displayed next to the names of each person in the system (Figure 114). This allowed players to quickly mouse-over the icon to review the individual's Adopter Type more quickly than clicking on the "REVIEW PEOPLE" button.



Figure 114. Screenshot Round 4, Level 2, Objective 1; Adopter Type icons

4.2.1.Q

In Round 2, players are told to focus their efforts on Michael (the Early Adopter) but are not forced to use Michael in Diffusion Activities. However, doing so greatly improves game performance. Consider the example illustrated in Figure 115. The player selected Michael for the Implement B activity. The activity was appropriate for Michael's current phase of adoption (Trial) because it allowed him to try the rewards system with his sales team on a limited basis. The outcome, as expected, resulted in Michael gaining an adoption point. This point happened to be the last point Michael needed and so he adopted the innovation. However, using Michael (the Early Adopter) resulted in others in the system being awarded adoption points as well. Specifically, because Michael gained a point, each team leader who was in the Interest Phase gained two points.

The screenshot shows a game interface with a calendar at the top (Jan to Dec). On the left, there's a 'Mentor' section with a profile picture and a list of activities: 'Information Activities' (Cost 1), 'Get Personal Info' (Cost 1), 'Diffusion Activities' (Cost 1), 'Business Lunch' (Cost 1), 'Implement A' (Cost 5), 'Implement B' (Cost 6), 'Pamphlet' (Cost 1), 'Ride Along' (Cost 1), 'Site Visit' (Cost 2), and 'Talk to' (Cost 1). A 'REVIEW PEOPLE' button is at the bottom of this list.

In the center, there's a 'List View' tab and a 'Detailed View' tab. The 'Detailed View' tab is active, showing a table of team leaders and their progress.

	Team Leader	Awareness	Interest	Trial	Adopter
A	Barbara				<input type="checkbox"/>
B	Elizabeth				<input type="checkbox"/>
C	Elliot				<input type="checkbox"/>
D	Michael				<input checked="" type="checkbox"/>
E	Ruth				<input type="checkbox"/>
F	Theodore				<input type="checkbox"/>

On the right, there's an 'Activity Area' section. It has a title 'Implement B' and a description: 'Team Leader selected: Michael'. Below this, it says 'Outcome: If the Team Leader selected is in the Trial phase, they implement the plan on a trial basis and find that sales increase dramatically. Gain 1 points for the Team Leader selected if he/she is in the Trial phase. If Michael gains a point in this way, all Team Leaders in the Interest phase gain 2 points. Cost: 6 week(s)'.

Figure 115. Screenshot Round 4, Level 2, Objective 1; Getting Michael to adopt

4.2.2 (Round 4, Level 2, Objective 2)

Objective 2 of Level 2 was developed for the first time in Round 4 and is described in the following sections (4.2.2.A through 4.2.2.H).

4.2.2.A

The initial message of Objective 2, Level 2 informs the player: “You did just fine on objective 1. Let’s see how you do with a little less help and a few more people.” This tells the player that a new scenario is being provided and the instructional support will be reduced.

The objective (Figure 116) charges the player with the task of convincing 12 doctors to adopt a new angioplasty procedure.

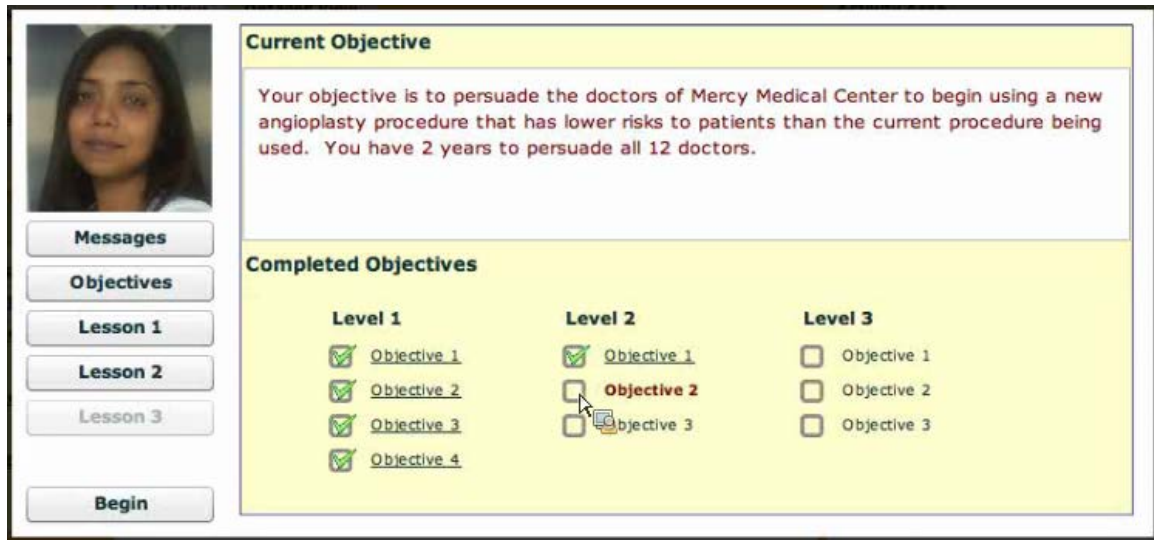


Figure 116. Screenshot Round 4, Level 2, Objective 2; Objectives

4.2.2.B

A mini-message was again given to the players to tell them to get information about all of the people in the system (Figure 117). Because this is not the worked-out example, following this advice was optional for the player. However, players who did not get information on everybody in the system discovered quickly that they are not able to target people they have not collected information on for diffusion activities.

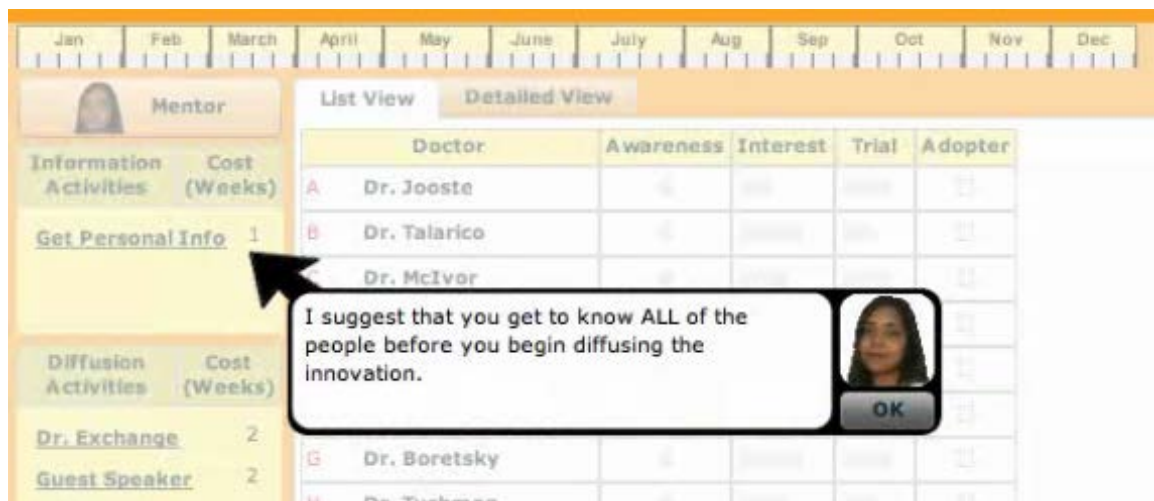


Figure 117. Screenshot Round 4, Level 2, Objective 2; Initial mini-message

4.2.2.C

Once the players collected all the information the “SORT PEOPLE” button appeared (Figure 118), they were provided with a mini-message informing them that they “may now use this activity to identify the Adopter Type of each person.”



Figure 118. Screenshot Round 4, Level 2, Objective 2; Mini-message about optional Sort People activity

4.2.2.D

Figure 119 shows the Sort People activity with all but one of the doctors sorted correctly. Notice that, even though the activity has not been successfully completed, the “Return to Game” button is already enabled. This is because the Sort People activity was optional in Objective 2.

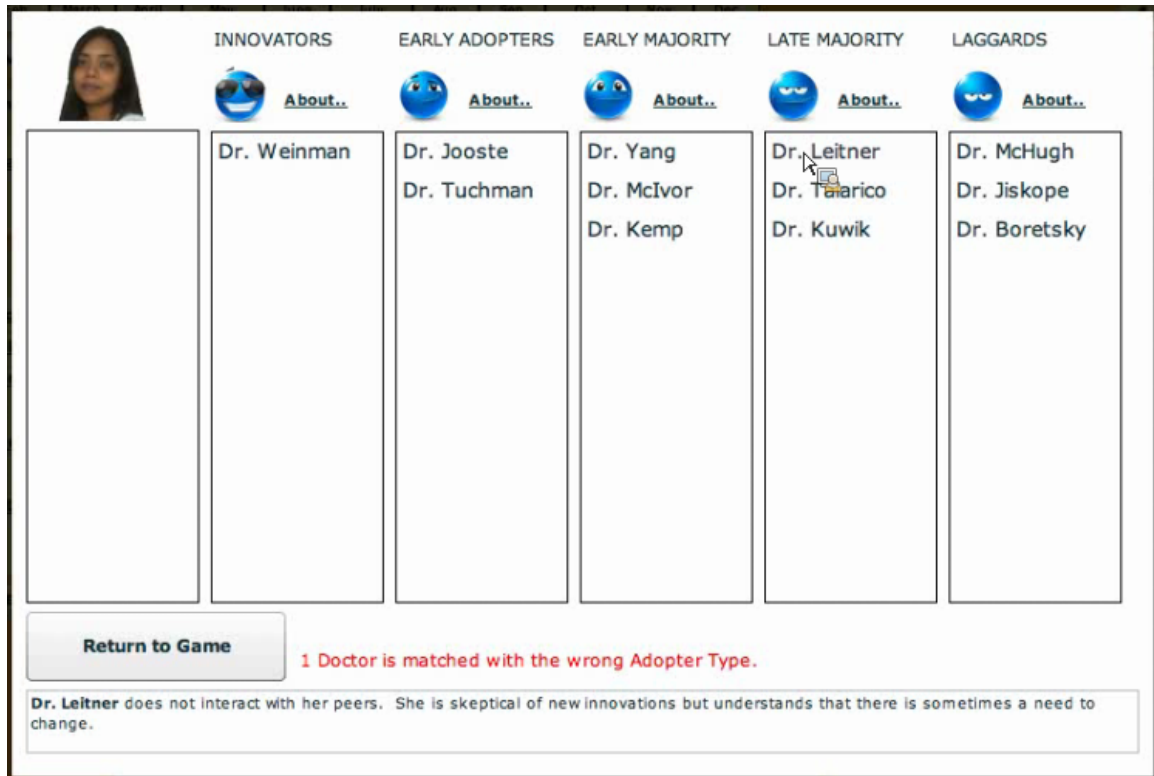


Figure 119. Screenshot Round 4, Level 2, Objective 2; One error in Sort People activity

4.2.2.E

After players' successfully completed the Sort People activity, they were once again encouraged to focus on Early Adopters (Figure 120). Also, notice the orange Adopter Type icons appeared in Objective 2 after the Sort People activity has been completed successfully just as they had in Objective 1.



Figure 120. Screenshot Round 4, Level 2, Objective 2; Mini-message encouraging player to focus on Early Adopters

4.2.2.F

While the players were not forced to target the Early Adopter in their diffusion efforts, mini-messages provided corrective feedback when the players made multiple activity selections without including an Early Adopter. Figure 121 shows a mini-message that appeared after the player made two consecutive choices which either did not include an Early Adopter, or did not include an activity that was appropriate for the selected Early Adopter's current phase of adoption.

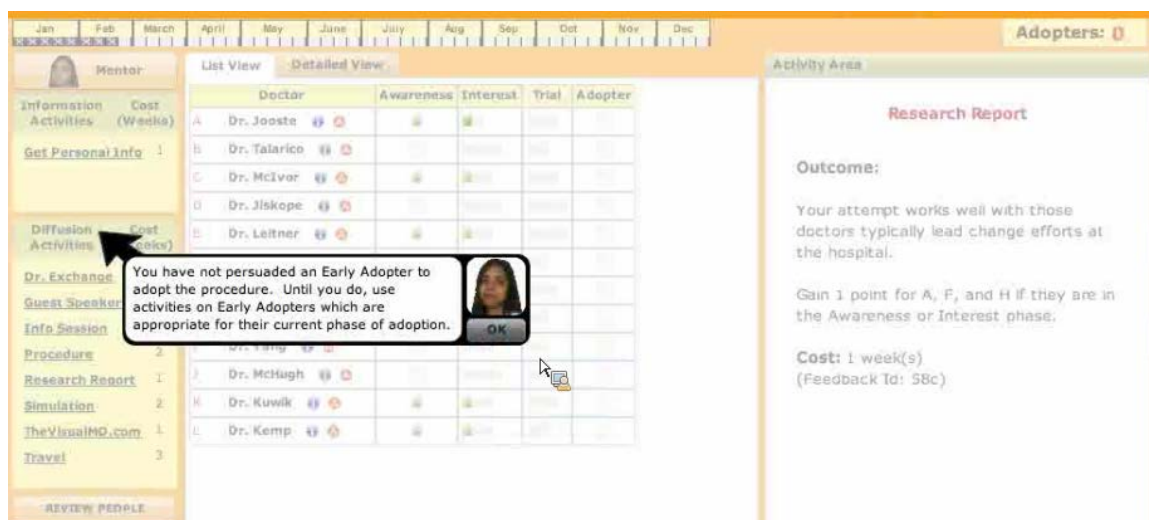


Figure 121. Screenshot Round 4, Level 2, Objective 2; Mini-message corrective feedback

4.2.2.G

Figure 122 provides a screenshot of Objective 2 just after both of the Early Adopters (Dr. Jooste and Dr. Tuchman) became adopters. In the Level 2 and Level 3 objectives, targeting Early Adopters for diffusion activities often had positive effects on others in the system (see 4.2.1.Q for an example). Additionally, once an Early Adopter adopted the innovation, the likelihood of diffusion activities being effective with others increased, regardless of whether or not an Early Adopter was included in the activity.



Figure 122. Screenshot Round 4, Level 2, Objective 2; Early Adopters adopted

Round 4 Findings

The time spent to play the game in Round 4 ranged from 62 to 198 minutes. This amount of time was much more than what the researcher had estimated and told participants to expect. Possibly because of this underestimation of time, two of the four Round 4 participants chose not to complete the post-test after finishing the gameplay session. The pre- and post-test scores of the other two Round 4 participants are provided in Table 13 along with their adjusted scores. As with all participants in the study, the maximum score on the pre- and post-test was 6 points. Round 4 participants played through the first two levels and were therefore expected to learn about Adoption Phases and Adopter Types. Therefore, their adjusted score was calculated based on the top two rows of the grading rubric (see Appendix G) for a maximum score of 4 points.

Table 13:

Round 4 Scores of Pre-/Post-tests

Participant	Pre-test	Post-test	Improvement	Adjusted Pre-test	Adjusted Post-test	Adjusted Improvement
11	0	4	4	0	2	2
12	2	4	2	2	4	2

The mean post-test score of 67% (4 out of 6 possible) was a 50% improvement over the mean pre-test score of 17% (1 out of 6 possible). The mean adjusted post-test score of 100% (4 out of 4 possible) was a 75% improvement over the mean adjusted pre-test score of 25% (1 out of 4 possible). This 75% improvement provides some evidence that playing the game results in learning the diffusion of innovations concepts that are

being tested — application of Adoption Phases and Adopter Types to diffuse an innovation throughout a group of people.

Many issues related to usability and learning came to light during the fourth round of data collection. Some of the more significant issues involve the need for players to attend to information which was being overlooked or ignored, confusion between the appropriateness and effectiveness of an activity, difficulty level of the sorting activities, and the need to provide players with more practice in applying the concept of Adopter Types to their diffusion efforts. These findings are discussed in the following sections along with the description of changes to the game made in Round 5.

Chapter 9: Design Case Round 5

The continued design and development of Round 5 was largely influenced by the findings from Round 4 and previous rounds. In Round 5, the re-designed DSG consisted of two levels. The first level, consisting of four objectives, was designed to aid players in learning about and applying the concepts of Adoption Phases to their efforts in diffusing an innovation. The second level, consisting of three objectives, was designed to aid players in learning about and applying the concepts of Adopter Types in their diffusion efforts.

5.1.1 (*Round 5, Level 1, Objective 1*)

5.1.1.A

In previous rounds, some players skipped past the objective description in one or more objectives before reading it. In at least one case, this was due to the player not noticing that the text had changed when they moved from the “Messages” screen to the “Objectives” screen within the Mentor Window. To make the change of text more noticeable to players, a different text color was used for all objectives in all levels of the game. For the “Messages” screen, the text was displayed in green (Figure123).

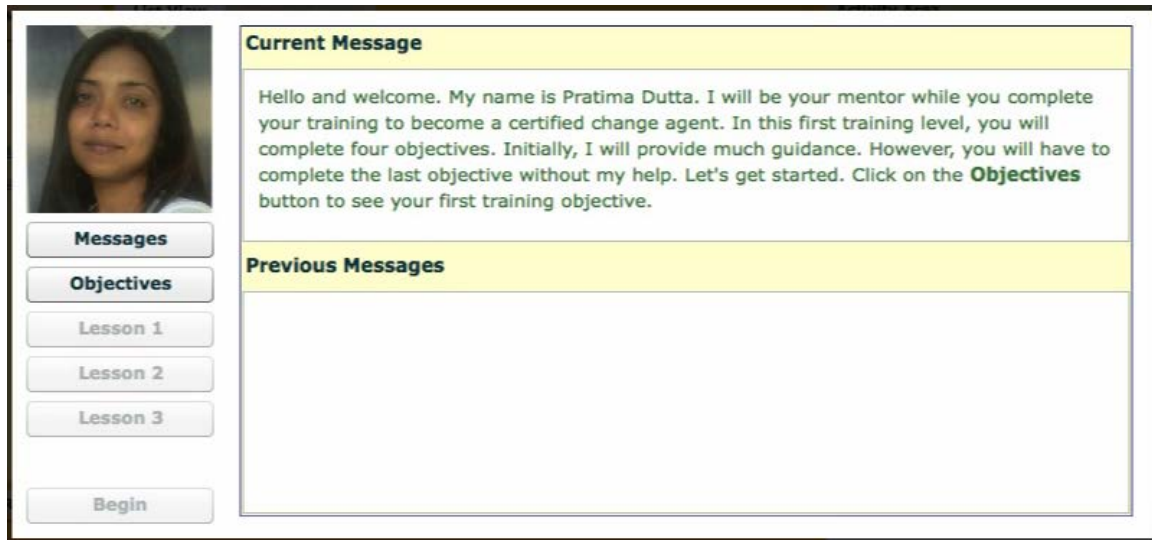


Figure 123. Screenshot Round 5, Level 1, Objective 1; Initial message

For the “Objectives” screen the text was displayed in red (Figure 124). This change in text color made it obvious to the player that new information was being presented when the “Objectives” button is first clicked.

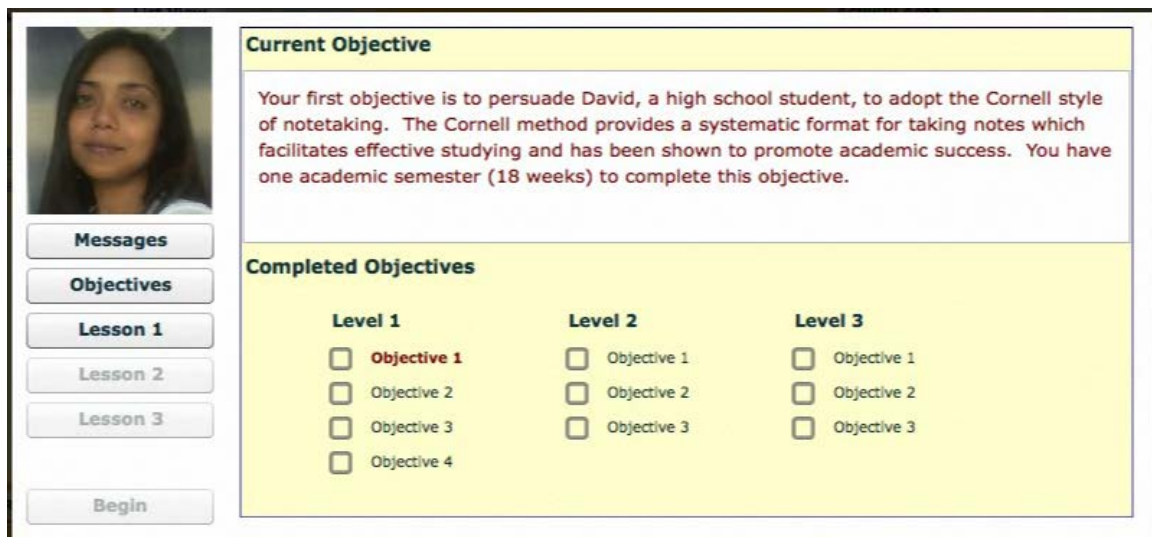


Figure 124. Screenshot Round 5, Level 1, Objective 1; Objective description

5.1.1.B

Confusion between the appropriateness and effectiveness of an activity was observed in several Round 4 game sessions. In the Activity Log as it existed in Round 3 and Round 4 (described in sections 3.1.1.E and 3.1.2.D), the meaning of the smiley face

(representing an appropriate activity choice) and the red X (representing an inappropriate activity choice) was often misunderstood as being an indication of effectiveness instead of appropriateness. For example, when an activity was effective but a red X was displayed to indicate it was not appropriate for the current phase of adoption, Participant 14 stated “Even though [using the activity] moved me to the Interest level, [the roll-over message] says [the activity] was not appropriate for the Interest Phase; so I was not clear on that.”

To resolve this confusion, the Activity Log was modified to use a happy or sad face to show appropriateness along with a red X or green check to show effectiveness (Figure 125).

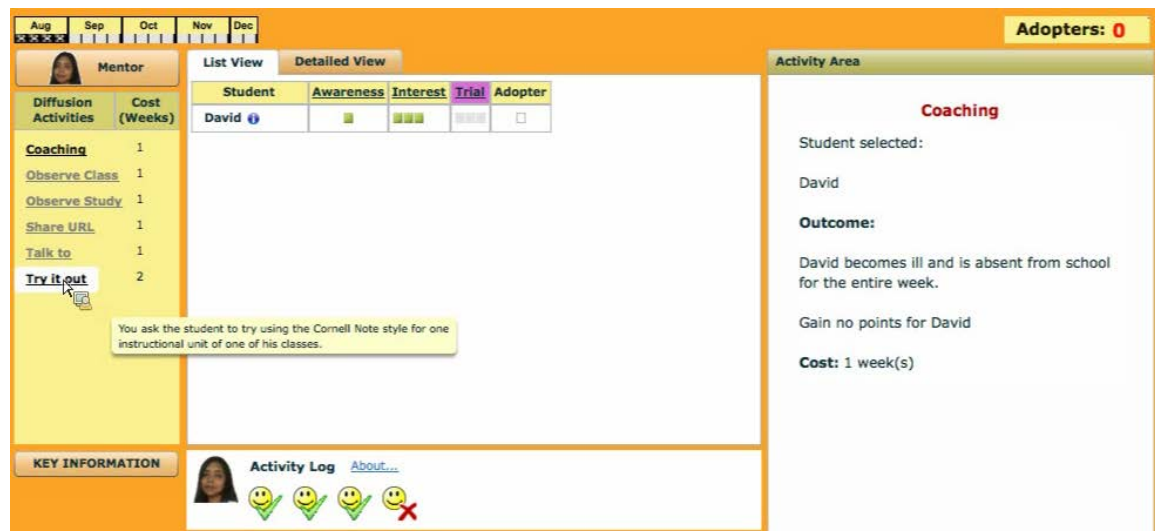


Figure 125: Screenshot Round 5, Level 1, Objective 1; Modified Activity Log

The Activity Log was re-designed to alleviate player’s misconceptions by visually showing that an activity’s appropriateness for a particular phase is not always consistent with the activity’s effectiveness. In Figure 125, the Activity Log shows that the first three activity choices were appropriate (happy faces) for the phase of adoption in which

they were used and effective (green checks) while the last choice was appropriate (happy face) for the current phase but ineffective (red X).

5.1.1.B

An issue that was revealed in several rounds of the study involved players becoming confused as to which phase of adoption an individual was in at any given moment in the game. Consider the example illustrated by Figure 125. David has all of the points needed in the Interest Phase but no points in the Trial Phase. Does this mean that David is currently in the Interest Phase or the Trial Phase? In Round 5, the current phase of adoption was highlighted in purple (Figure 125) to ensure the player understood which phase of adoption the individual in the game was in.

5.1.2 (*Round 5, Level 1, Objective 2*)

5.1.2.A

In Round 4, the Sort Activities activity was optional for the player. However, participants who completed the activity reported in the interview that the activity was integral to their learning. Therefore, in Round 5 players were required to complete the Sort Activities activity prior to employing any diffusion activities. The activity itself (described in 4.1.2.C) was also slightly modified to include highlighting and more helpful information about activities which were sorted incorrectly. Both of these modifications are described in 5.1.3.A.

5.1.2.B

An issue that plagued some players in Round 4 was that the Probability Spinner could land on an unlucky outcome repeatedly. This was unique to Objective 2 because the algorithm for randomly selecting from the possible outcomes was modified to

incorporate the Probability Spinner. Consider the example illustrated by Figure 126. The only Objective 2 diffusion activity appropriate for the Trial Phase is the “Promo Offer”. This activity requires two weeks to use and has 1/3 of a chance of being ineffective every time it is used. In this case, the player did get the unlucky outcome. Because the probability for outcomes do not change based on previous outcomes, it is possible for players to get unlucky multiple times. This happened in several game sessions and in at least one case caused the player to fail the objective (run out of time before persuading Micah to adopt) without having made any inappropriate choices in activity selection. To address this issue, the game mechanics were modified in Objective 2 so that, just as in the other objectives, an outcome would never be repeated twice in a row.

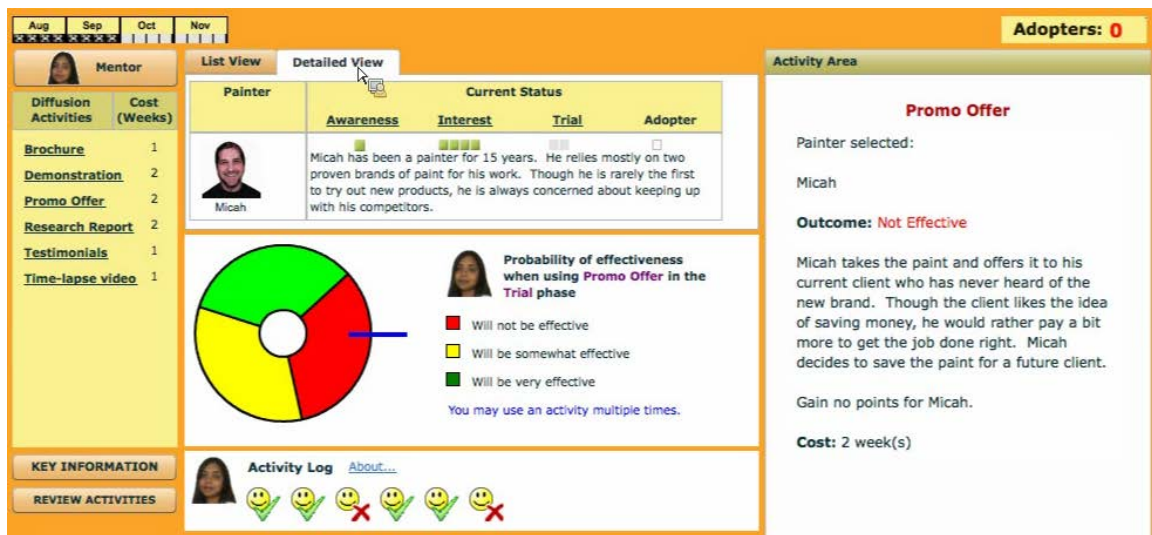


Figure 126. Screenshot Round 5, Level 1, Objective 2; Unlucky outcomes

5.1.3 (Round 5, Level 1, Objective 3)

5.1.3.A

Tweaking the timing and content of instruction being provided was needed in Round 5 as it was in every other round. One example of this relates to the sorting

activities (both the Sort Activities activity and the Sort People activity) which, in Round 4, appeared in several Level 1 and Level 2 objectives. Round 4 data revealed that the sorting activities needed modifications to lessen the frustration of players and avoid a trial-and-error approach to sorting the activities into appropriate phases of adoption and the people into the appropriate Adopter Types. Specifically, players needed support once they had all but a few of the items sorted correctly. In Round 5, the last incorrectly sorted item(s) were identified for the player so that they would know which items remained under the wrong category. In the example illustrated in Figure 127, the player has sorted all activities correctly except for one. Therefore, the feedback provided tells the player which activity, “Infomercial” in this case, is under the wrong phase of adoption.

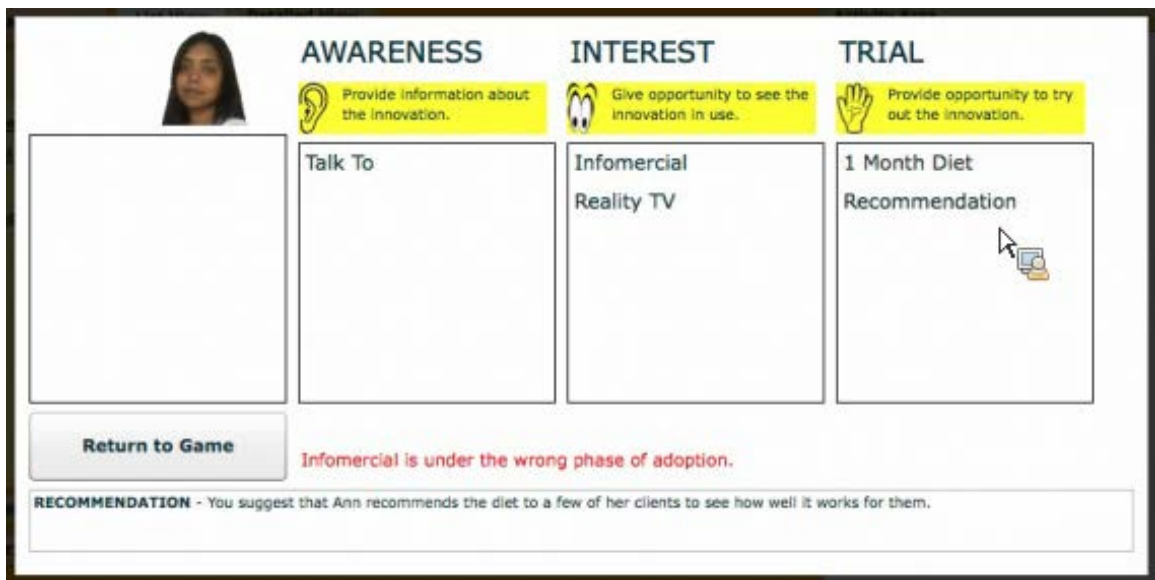


Figure 127. Screenshot Round 5, Level 1, Objective 3; Sort Activities activity

5.1.3.B

Also note that in Figure 127 the definitions for the Adoption Phases are highlighted in yellow. In Round 5, these definitions were highlighted at the moment in which the player finished sorting (no activities remained in the left column) but had one or more activities sorted incorrectly. This method of drawing player’s attention to the

definitions was added in because several participants from previous rounds continued to apply their own meanings for awareness, interest, and trial that were not consistent with the Diffusion of Innovations theory.

5.1.4 (*Round 5, Level 1, Objective 4*)

5.1.4.A

The fourth objective was almost completely unchanged in Round 5. Because the level of challenge was too high in Round 4, two weeks were added to the calendar to decrease the difficulty of the objective. Additionally, the concluding mini-message (Figure 128) that appears once the players pass this final objective of Level 1 was modified to introduce a new game element, the wrap-up activity.

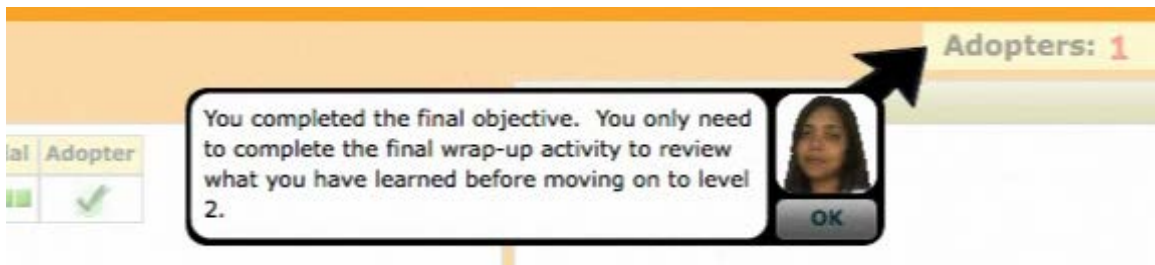


Figure 128. Screenshot Round 5, Level 1, Objective 4; Mini-message introducing the Level 1 wrap-up activity

5.1.W (*Round 5, Level 1, Wrap-up*)

5.1.W.A

The Level 1 wrap-up activity (Figure 129) was added because some players in Round 4 were able to move on to the second level without a full understanding of what types of activities were most appropriate for each phase of adoption. The wrap-up activity required the players to move the three blue boxes representing each phase of adoption (Awareness, Interest, and Trial) to the appropriate activity descriptions

provided. If the player pressed the “BEGIN LEVEL 2” button prior to correctly completing the matching activity, a message informed the player that they could not progress until they have correctly matched each Adoption Phase to its appropriate activity description. Once the matching was correctly done, the player could progress to the second level.

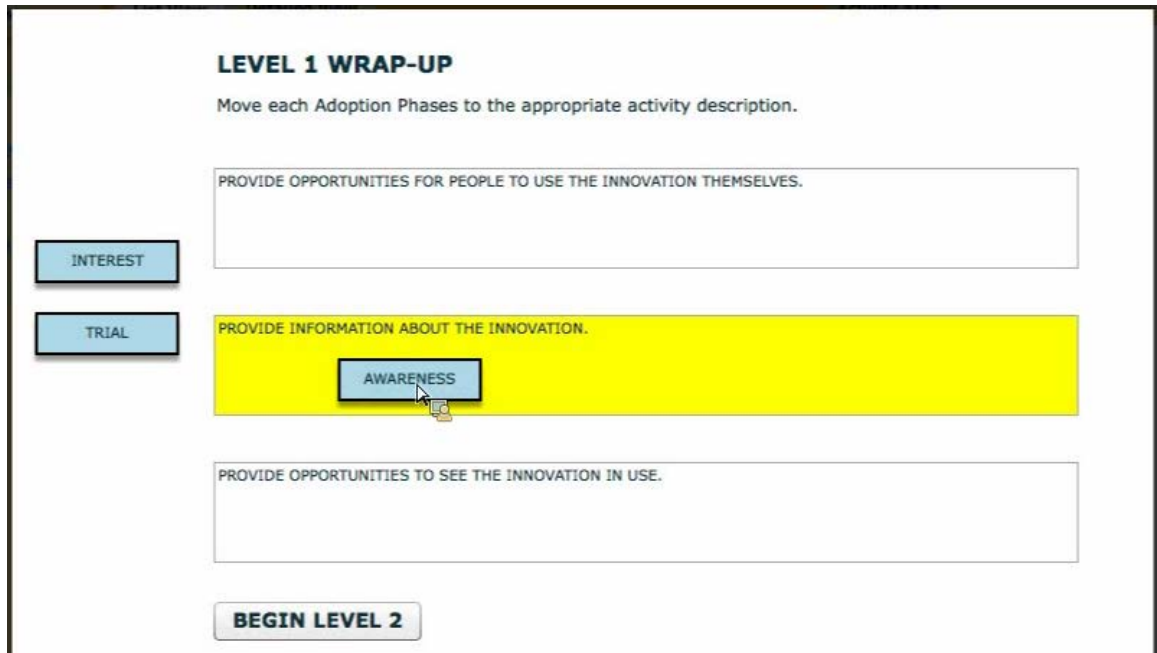


Figure 129. Screenshot Round 5, Level 1, Wrap-up

The wrap-up activity gave players one last opportunity to reflect on what they should have learned while completing the level. Because players are introduced to, and experience, so much in the first level, the wrap-up activity serves as an interactive means to review the most important information that should be taken away from their Level 1 experience.

5.2 (Round 5, Level 2)

In Round 5, a third objective and a wrap-up activity were developed for Level 2. The modifications to the first two Level 2 objectives are described in sections 5.2.1 and

5.2.2 while the new objective and Level 2 wrap-up activity are described in sections 5.2.3 and 5.2.W.

5.2.1 (*Round 5, Level 2, Objective 1*)

The first objective of Level 2 was last described in 4.2.1. In Round 5, several changes to the objective were made.

5.2.1.A

The first change to the first objective of Level 2 was the inclusion of the “KEY INFORMATION” button. A mini-message was used to draw players’ attention to the button and inform them that it has been updated to include what they had just learned from the Level 2 instructional video (Figure 130).

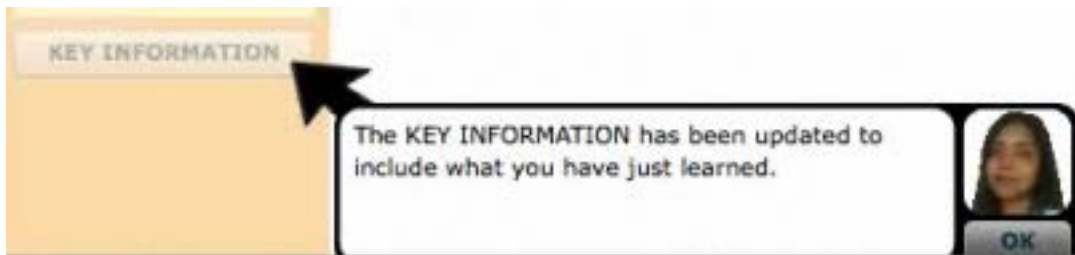


Figure 130. Screenshot Round 5, Level 2, Objective 1; Mini-message about KEY INFO

By moving the mouse over this button, a player is able to quickly review the mental model (that was introduced in the Lesson 2 instructional video) needed to complete the objectives of Level 2, without having to return to the video (Figure 131).

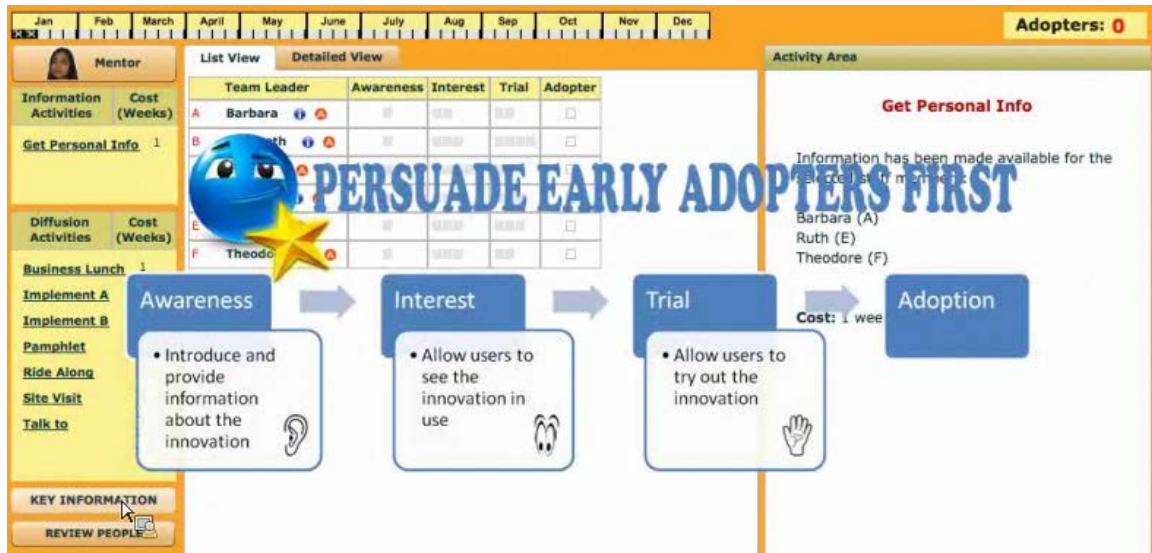


Figure 131. Screenshot Round 5, Level 2, Objective 1; Level 2 KEY INFORMATION button and mental model

5.2.1.B

One issue that arose in previous rounds of the study was the confusion some players had when suddenly introduced to activities which required the selection of multiple people. This was true even though the activity descriptions themselves instructed the player on how many people to select. For example, Participant 12 was not initially able to use activities such as “Business Lunch” and “Site Visit” because they did not understand that more than one person needed to be selected and because the “Continue” button does not appear until the correct number of people have been selected. To address this issue in Round 5, text emphasized in blue was provided in the Activity Area to inform the player how many people needed to be selected for the selected activity (Figure 132). In the example illustrated by Figure 132, the player used the “Get Personal Info” activity. The blue text in the Activity Area told the player to “Select 3 Team Leaders for this activity”.

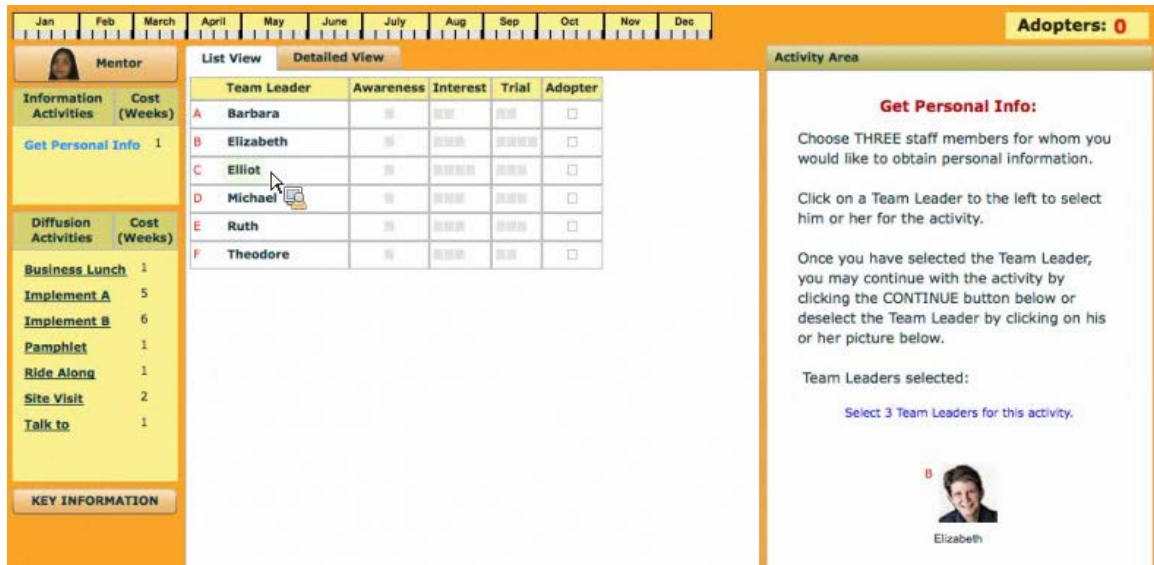


Figure 132. Screenshot Round 5, Level 2, Objective 1; Emphasis on number of people who need to be selected for an activity

5.2.1.C

In Round 5, the Sort People activity (described in 4.2.1.K through 4.2.1.L) was slightly modified to include a “Show Distribution” link which was presented to the player through a mini-message (Figure 133).

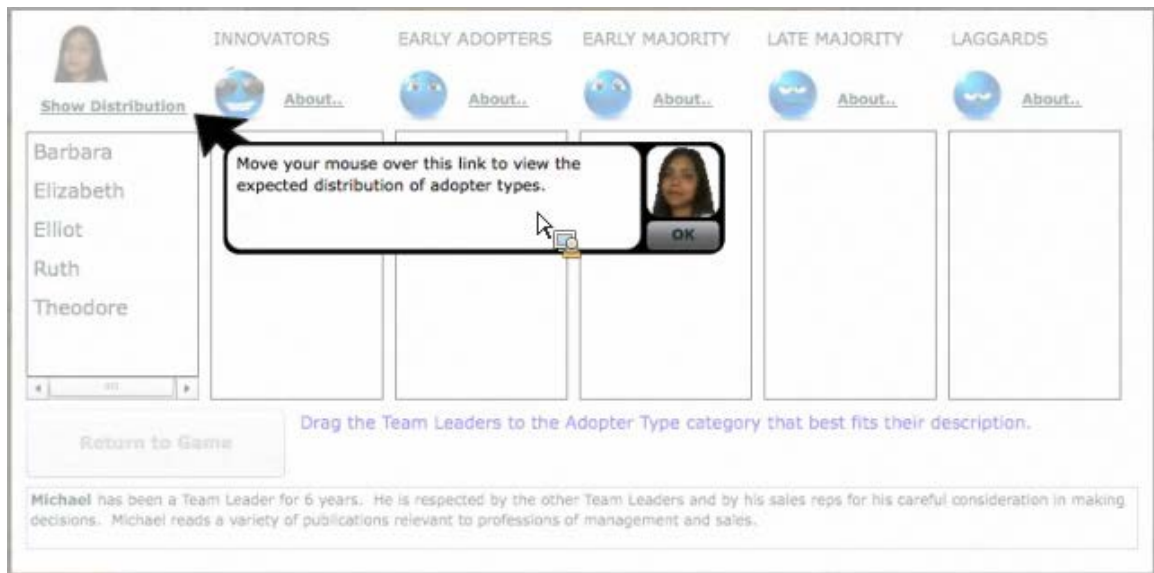


Figure 133. Screenshot Round 5, Level 2, Objective 1; mini-message for Show Distribution link

By moving the mouse over the “Show Distribution” link (Figure 134), players are able to view the expected distribution of adopter types based on the proportions that were provided in the instructional video (4.2.1.E). This new game element was added to help players complete the Sort People activity by showing them roughly how many people belong in each Adopter Type category and to review the information learned in the video related to the typical distribution of Adopter Types within a social system.

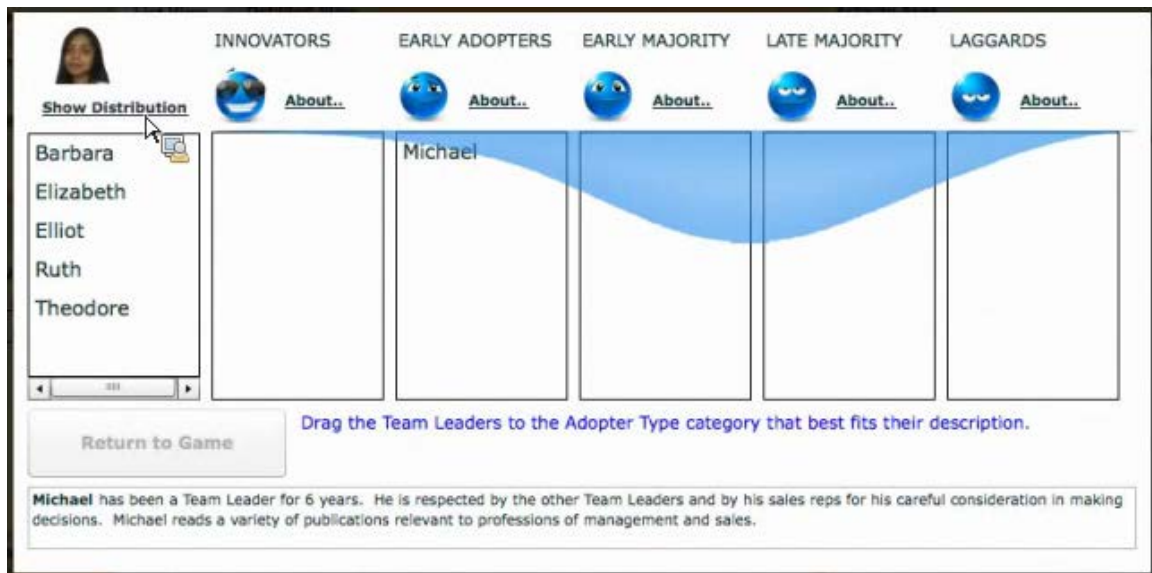


Figure134. Screenshot Round 5, Level 2, Objective 1; Showing the distribution

5.2.2 (Round 5, Level 2, Objective 2)

All the changes that were made to the first objective of Level 2 (described in sections 5.2.1.A through 5.2.1.C) were also made in the second objective of Level 2. Besides these changes, few modifications were made to the second objective of Level 2 during Round 5.

5.2.3 (Round 5, Level 2, Objective 3)

The third level of Level 2 was developed in Round 5 of the study. As the last objective of the level, no instructional supports (sorting activities, Adopter Type icons, mini-messages, etc.) were provided.

5.2.3.A

In this third and final objective of Level 2, players must apply what they have learned to a new task described to them in the “Current Objective” (Figure 135) with no instructional support. The objective requires the player to persuade a group of fireman to adopt a new innovation; Thermal Performance Indicators.

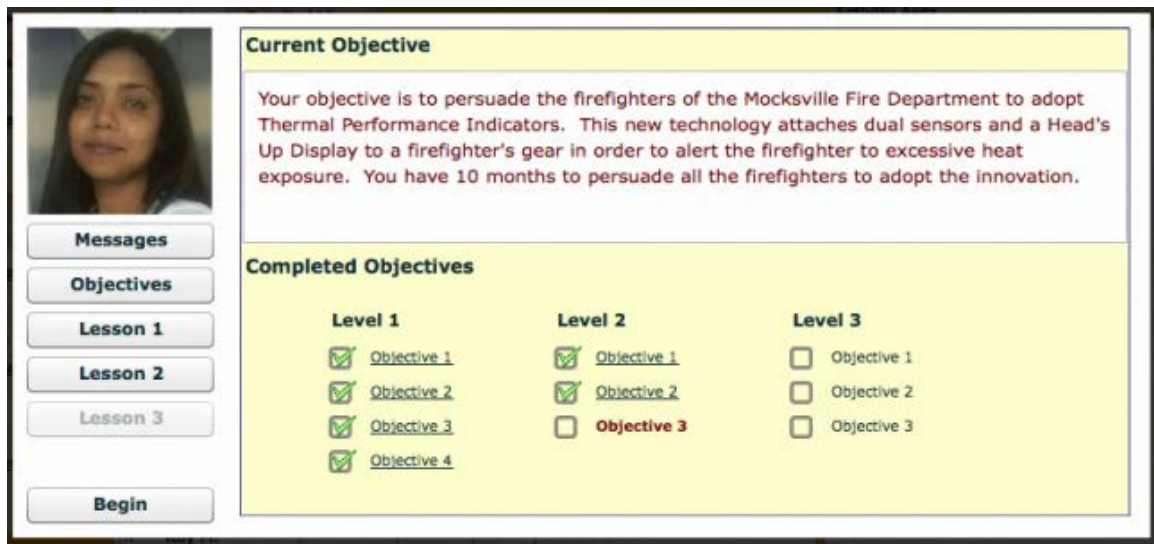


Figure 135. Screenshot Round 5, Level 2, Objective 2; Objective description

5.2.3.B

In Objective 3, players again may get to know the people in the group (three at a time) by using the Get Personal Info activity (Figure 136). However, once they have collected the information, no Sort People activity or Adopter Type icons are made available as they were in Objective 2 of Level 3.

The screenshot displays a game interface for Round 5, Level 2, Objective 3. At the top, a calendar shows the months from February to November. Below the calendar, there are two tabs: "List View" and "Detailed View". The "List View" tab is active, showing a table of firefighters with columns for Firefighter, Awareness, Interest, Trial, and Adopter. The table lists 18 firefighters (A through R) with their names and various icons indicating their status. To the right of the table is an "Activity Area" with the title "Get Personal Info:". It contains instructions: "Choose THREE staff members for whom you would like to obtain personal information. Click on a firefighter to the left to select him or her for the activity. Once you have selected the firefighter, you may continue with the activity by clicking the CONTINUE button below or deselect the firefighter by clicking on his or her picture below." Below the instructions, three firefighter portraits are shown: Jeff L., Jim K., and Josh M., each with a letter (G, H, I) above them. A "Continue" button is at the bottom of the activity area.

Firefighter	Awareness	Interest	Trial	Adopter
A Chad L.				
B Frank C.				
C Greg F.				
D Jackie C.				
E Jason M.				
F Jason P.				
G Jeff L.				
H Jim K.				
I Josh M.				
J Lonnie H.				
K Mark W.				
L Michael C.				
M Michael F.				
N Ray M.				
O Rhonda W.				
P Rodney P.				
Q Scott C.				
R Victor R.				

Figure 136. Screenshot Round 5, Level 2, Objective 3; Getting Personal Info

5.2.3.C

In some of the objectives which involve multiple people, an activity exists which may only be used with a person who has already adopted the innovation. “Training Demo” is one such activity that exists in third objective of Level 2. The “Training Demo” activity requires that an adopter be selected to give the demo for all the other firefighters to see. By providing an opportunity to “see the innovation in use”, the players can potentially influence many people in the Interest Phase at one time. This is the case illustrated by Figure 137. The player selected Chad L. (an adopter) to give a training demo at an opportune time in the game (while many were in the Interest Phase). The outcome was that almost everybody in the system gained three adoption points (signified by the bright green squares). This activity was especially effective because the adopter that was chosen to lead the demonstration was an Early Adopter and therefore had a high degree of opinion leadership in the social system.



Figure 137. Screenshot Round 5, Level 2, Objective 3; Effectively using Early Adopters to raise Interest of others

5.2.W (Round 5, Level 2, Wrap-up)

5.2.W.A

Just as a Level 1 wrap-up activity was added in Round 5 for players to review information relevant to the Adoption Phases, a Level 2 wrap-up activity was added for players to review information relevant to Adopter Types. The Level 2 wrap-up required players to match individual characteristics to the appropriate adopter types (Figure 138). Once all the characteristics were correctly matched, the “Begin Level 3” button allowed the players to progress to the next level of the game.

LEVEL 2 WRAP-UP

Move each characteristic to the most appropriate adopter type.

Traditional and resistant to change.

Able to cope with a high degree of uncertainty.

Skeptical. Influenced by peer pressure and economic necessity.

Attention to Mass Media. Discrete use of innovations.

Almost no opinion leadership.

High degree of success in implementing innovations.

BEGIN LEVEL 3

Characteristics of: **Innovators**

1.

2.

Characteristics of: **Early Adopters**

1. Highest Opinion Leadership.

2.

3.

Characteristics of: **Early Majority**

1. Frequent interaction with peers but seldom in leadership roles.

Characteristics of: **Late Majority**

1.

Characteristics of: **Laggards**

1.

Figure 138. Screenshot Round 5, Level 2, Wrap-up

Round 5 Findings

The pre- and post-test scores of the two Round 5 participants are provided in Table 14 along with the adjusted scores. As with all participants in the study, the maximum score on the pre- and post-test was 6 points. Round 5 participants played through the first two levels and were therefore expected to learn about Adoption Phases and Adopter Types. Therefore, the adjusted score was calculated based on the top two rows of the grading rubric (see Appendix G) for a maximum score of 4 points.

Table 14:

Round 5 Scores of Pre-/Post-tests

Participant	Pre-test	Post-test	Improvement	Adjusted Pre-test	Adjusted Post-test	Adjusted Improvement
15	2	4	2	2	4	2
16	4	4	0	4	4	0

Because both participants performed well on the pre-test, there was little room for improvement. Still, the mean adjusted post-test score of 100% (4 out of 4 possible) was a 25% improvement over the mean adjusted pre-test score of 75% (3 out of 4 possible) providing some evidence that playing the game results in learning the diffusion of innovations concepts that are being tested — the application of Adoption Phases and Adopter Types to diffuse an innovation throughout a group of people.

Both participants in Round 5 reported in their interview that they had very positive feelings about the version of the DSG they played and the various instructional elements that were embedded. Participant 16 noted that she liked the second level much more than the first because of the added complexity required to deal with multiple people. This participant liked the Probability Spinner but felt it made the game less challenging and that it should only appear if the player is “really stuck”. Participant 16 also stated in the interview that the sorting activities, the Adopter Type icons in the list view, the wrap-up activity, the instructional video, and the mini-messages were all helpful for learning. The participant felt that the support at the beginning of each level and the gradual reduction of that support increased their confidence. Participant 16 also

liked the Game Log, but only understood the meaning of the indicators of effectiveness (red X and green check) and so disregarded the indicators of appropriateness (sad and smiley faces).

Participant 15 also provided evidence that the game was appealing and the instructional content was engaging and helpful. This participant thought the interface and game mechanics were clear and liked the pictures of people, the persona of the mentor, the Probability Spinner, the sorting activities, and the instructional video. Participant 15 did understand the effectiveness and appropriateness indicators used in the Activity Log. This participant cited game elements that were created from and are consistent with the 4C/ID Model as being the most helpful for learning — including the repetition of tasks, the variation between tasks, and the building from simple to complex concepts. Additionally, participant 15 felt the Probability Spinner was effective in showing the unpredictability and “the human factor” of the game and the sorting activities were helpful as an advanced organizer. When asked what elements of the game were not helpful for learning, the participant said “Nothing... I felt it was clear” but went on to make a suggestion that some corrective feedback should be given to players when they have to repeat an activity.

A few minor issues were revealed in the Round 5 game sessions and interviews which required slight modifications to the first two levels. However, the significant change to the game after Round 5 was the addition of the third level of the game. This final level of the game included the additional Diffusion of Innovations concept of Social Networks.

Chapter 10: Design Case Round 6

The changes to the first two levels in Round 6 were relatively minor (e.g. fixing minor bugs and correcting spelling and grammar errors). However, Level 3 was completely developed during this sixth and final round of the study. A detailed review of the first two levels is provided in sections 6.1 through 6.2.W so that the reader may get a comprehensive understanding of each objective in the final re-designed DSG after all Formative Research cycles were completed. The new level (Level 3) is described in detail beginning with Section 6.3. Together, sections 6.1 through 6.3.2 provide a summative description of the final version of the entire re-designed DSG.

6.1 (*Round 6, Level 1*)

The first level of the final version of the re-designed DSG includes four objectives which require the player to move a single individual through the Adoption Phases of Awareness, Interest, and Trial to persuade them to adopt an innovation. As with all the objectives in the three levels created, the innovation, context, and diffusion activities vary from one objective to the next, providing the player an opportunity to apply what they have learned to diverse situations.

To successfully complete the objectives in Level 1, players must understand the concept of Adoption Phases and how to select activities that are appropriate for an individual's current phase of adoption. Before players set out to complete their objectives, they are provided with the information they need to successfully complete the Level 1 objectives. This information is provided via an instructional video and an

illustration of the mental model (Figure 139). Consistent with the 4C/ID Model, this *supportive information* is accessible by the player at any time during gameplay.

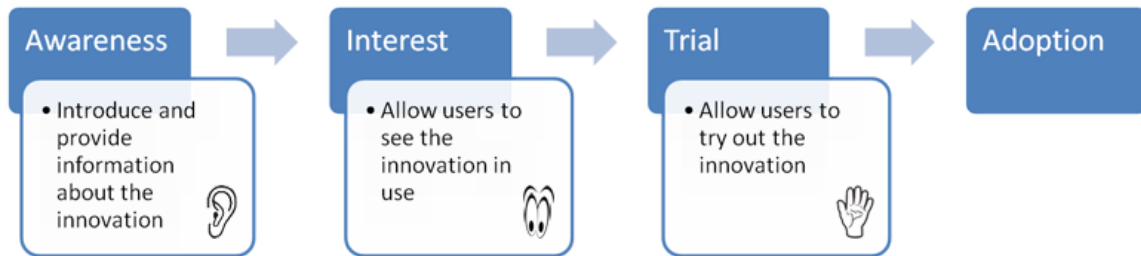


Figure 139. Mental model needed for players to complete the objectives in Level 1

6.1.1 (Round 6, Level 1, Objective 1)

The first objective given to the player requires them “to persuade David, a high school student, to adopt the Cornell style of note taking.” In this objective, the player must persuade a single individual (David) to adopt an innovation (Cornell style of note taking) by selecting appropriate activities which will be effective in progressing him through the Awareness, Interest, and Trial phases. The player is given 18 weeks of game time (one academic semester) to complete the objective.

Consistent with the 4C/ID Model, the use of mini-messages via a virtual mentor (Figure 140) was used to provide the *procedural information* (including instructions on how to play the game) in a just-in-time fashion. Though mini-messages exist throughout the game, the first objective has the most. This is because the learner is being provided with information on how to play the game for the first time and because, as the first objective of the level, the amount of instructional support needed by the player is high.



Figure 140. Screenshot of mini-message provided during Objective 1

The first objective was designed to be a gamified version of a worked-out example. The player still has the ability to interact, or ‘play’, the game but is forced by the mentor to make only appropriate choices. In addition to providing instructions on how to play the game, the mini-messages are used to explain why particular activities are appropriate for the individual’s current phase of adoption.

There are several observable differences between the original DSG (Figure 5) and the first objective of the re-designed DSG (Figure 141). In the first objective of the re-designed version, there are no Information Activities. Because there is only one person that needs to be persuaded, the concepts of Adopter Types and Social Networks are not introduced.

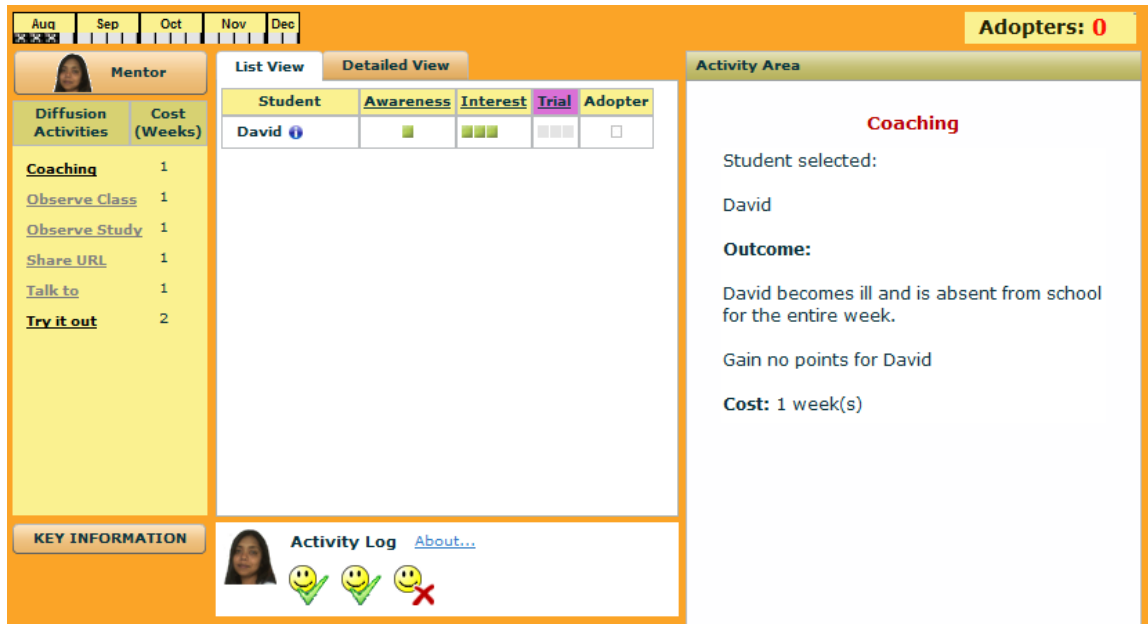


Figure 141. Screenshot of Level 1, Objective 1

Also, the first objective of the re-designed version has new elements that the original DSG did not. There is a button for the Mentor which the player may click on to review the objective, previous mentor messages, and the instruction video; all of which did not exist in the original DSG. The “KEY INFORMATION” button was introduced to allow players to review the mental model of the first level. An Activity Log provides the player with information about the appropriateness and effectiveness of each activity they use. In addition to these new elements, the first objective of the re-designed version differs from the original DSG in that it restricts user actions. Because the first objective was designed as the work-out example for Level 1, only the activities which are appropriate for David’s current phase of adoption are enabled while those which are not are disabled (grayed out).

6.1.2 (Round 6, Level 1, Objective 2)

The second objective charges the player with the task of persuading an exterior house painter named Micah to adopt a new paint formulated to withstand severe weather conditions. The supportive information (the video and mental model) remains unchanged from Level 1, but the objective, timeline, and available diffusion activities are new. Also, the number of mini-messages providing instruction is reduced.

The persistent supportive information, variation in context, and reduction of instructional aid are all consistent with the 4C/ID Model. However, results from early participants in the study revealed a need for providing additional help in selecting appropriate activities for each phase of adoption and a need to make the stochastic nature of the game's feedback transparent to the player.

To address the need for providing the player with information about how to select appropriate activities for each phase of adoption, a Sort Activities activity was added (Figure 142). This activity is consistent with the 4C/ID Model in that it provides *part-task practice* to the player to help them develop a skill in which they should have a high degree of automaticity in applying. Players are forced to correctly complete the Sort Activities activity before beginning the objective.

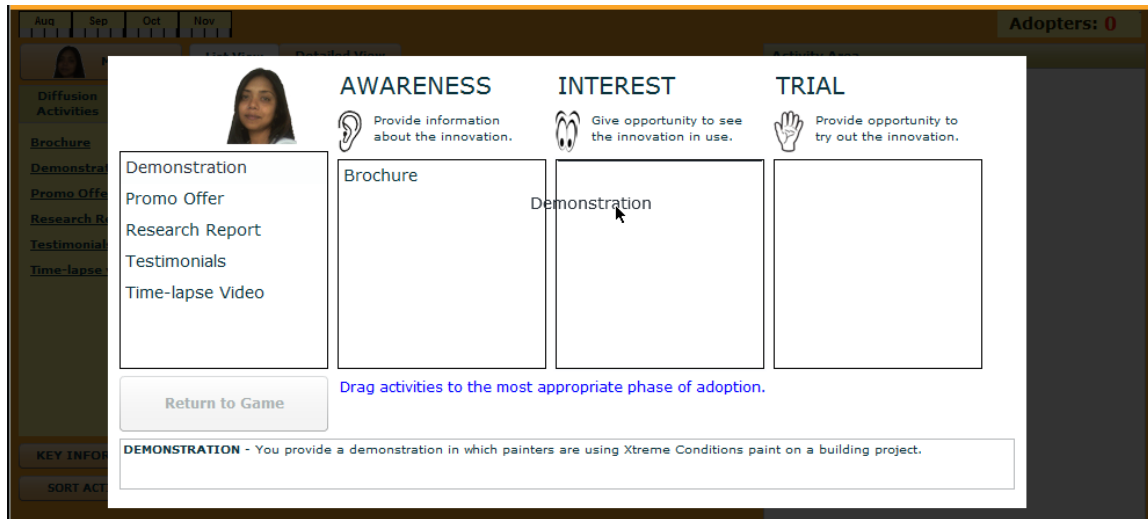


Figure 142. Screenshot of the Sort Activities activity in Level 1, Objective 2

Mini-messages were used to address the need for players to understand that the results of their actions and corresponding feedback are stochastic in nature. One mini-message designed to help player understand this, for example, appears the first time the player uses an appropriate activity for Micah’s current phase of adoption without success. The message states: “Remember, using an appropriate activity does not guarantee positive results. Don’t be discouraged. Keep selecting appropriate activities for the current phase of adoption. You may, and sometimes will need to, repeat the same activity.” Another mini-message attempts to focus the player on the information in the Activity Log (Figure 143) which is designed to help the player understand that selecting an appropriate activity (signified by a happy face) can sometimes be ineffective (signified by a red X).

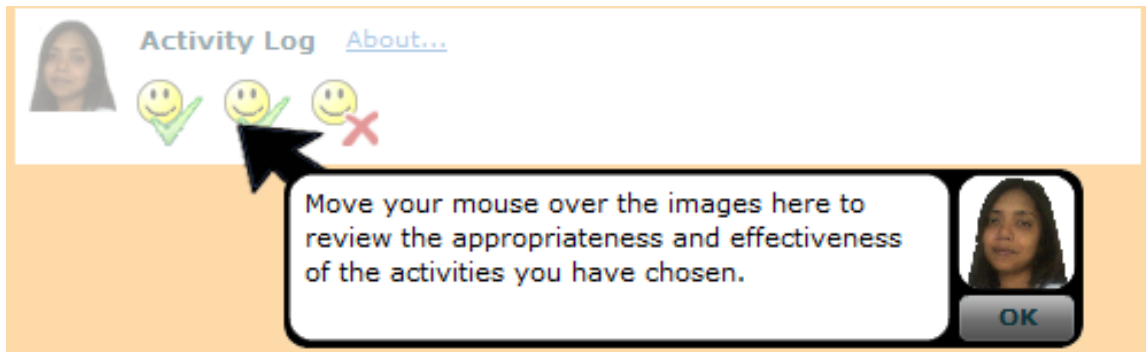


Figure 143. Screenshot of the Activity Log and instructional mini-message in Level 1, Objective 2

The mini-messages and Activity Log were found through the iterative cycles of research, design, and development to be insufficient in helping the player grasp the stochastic nature of the game. Therefore, a Probability Spinner was added (Fig. 144) which provided players with the probability of effectiveness for using a particular activity for the current phase of adoption. Once the player presses the “Continue” button to use an activity, the wheel spins and randomly lands on one of the possible results.

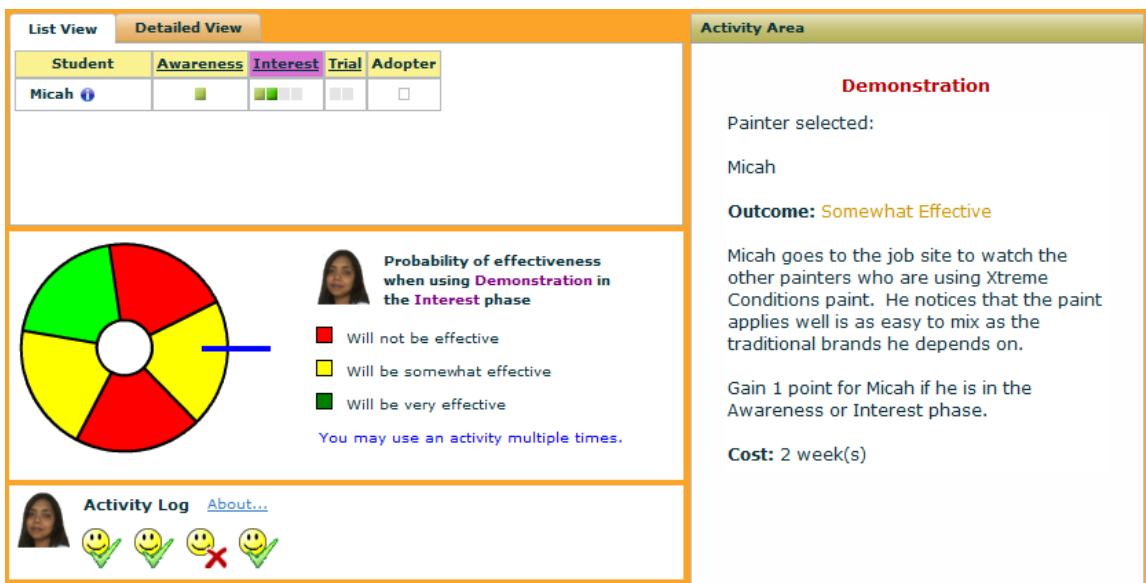


Figure 144. Screenshot of the Probability Spinner in Level 1, Objective 2

If the Probability Spinner lands on a green area, the outcome will be very effective and result in two or three adoption points. If the Probability Spinner lands on a yellow area,

the outcome will be somewhat effective and result in one adoption point. If the Probability Spinner lands on a red area, the outcome will not be effective at all and therefore result in no adoption points. Consider the turn that was just taken by a player which is demonstrated in Figure 144. The player used the “Demonstration” activity to try to persuade Micah to adopt an innovation. The activity was appropriate (the last image in the Activity Log is a smiley face) for Micah’s current Adoption Phase of Interest (highlighted in purple) because it allowed Micah to see the innovation in use. The result was somewhat effective as indicated by the green check on the last image in the Activity Log, the yellow color which the Probability Spinner landed on, and the outcome in the feedback panel which states “Somewhat Effective”. Therefore, the player earned one adoption point (indicated by the bright green square) in this turn.

The number and relative proportion of each color reflects the appropriateness of the selected activity for Micah’s current phase of adoption. In Figure 144, the “Demonstration” activity is being used on Micah who is in the Interest Phase. In this case, the activity is appropriate but still has 40% chance of being ineffective. Generally, appropriate activities have a higher chance than this of being effective in the game. If an inappropriate activity is selected for the current phase of adoption, the chance of being effective is generally much lower. In many cases, the Probability Spinner will be completely red because an activity would have no chance of being effective. This would be the case if, for example, a “Brochure” was given to Micah while he was in the Trial Phase.

6.1.3 (Round 6, Level 1, Objective 3)

In the third objective, the player is provided with new diffusion activities and charged with persuading Ann, a fitness specialist, to begin recommending the “Spice of Life” diet plan to her clients. The supportive information (instructional video and mental model) remains in this level but other instruction is reduced (e.g. the amount of help provided through mini-messages) or removed completely (e.g. the Probability Spinner). The Sort Activities Activity remains but is now optional for the player to use.

6.1.4 (Round 6, Level 1, Objective 4)

In the fourth objective, the player must persuade Jake to buy a digital camera to replace his non-digital camera before he leaves for vacation. This is the last objective of Level 1 and therefore, as prescribed by the 4C/ID Model, the player is provided no instructional support except for the supportive information (the instruction video in this case) which is persistent throughout the level. Figure 145 provides a screenshot of this objective.

Weeks before Vacation [Progress Bar]

Adopters: 0

Mentor

Diffusion Activities	Cost (Weeks)
Loan	1
News Article	1
Online Video	1
Phone Call	1
Store Demo	2
Workshop	1

	Awareness	Interest	Trial	Adopter
Jake ⓘ	■	■ ■ ■	■ ■ ■ ■	<input type="checkbox"/>

Activity Area

Online Video

Person selected:
Jake

Outcome:
Jake watches the video and becomes a bit more interested.
Gain 1 point for Jake if he is in the Awareness or Interest phase.
Cost: 1 week(s)

Figure 145. Screenshot of Level 1, Objective 4

In each objective, if the player fails to successfully complete the objective they must repeat the activity until they are successful. In the fourth objective, if the player fails to persuade Jake to adopt the innovation in the time allotted, the player is forced to complete the Sort Activities activity to correct any misconceptions that were formed about which activities are most appropriate for each phase of adoption. Once, they restart the objective, the Sort Activities activity is again removed.

6.1.W (*Round 6, Level 1, Wrap-up*)

A wrap-up activity was added at the end of Level 1. Though the 4C/ID Model does not prescribe providing a summary of what was learned to the learner, this design decision was made to address an issue that was revealed in the early rounds of the study. Players had learned so much related to the technical part of playing the game, that some of them were not retaining the primary concepts they were to learn (how to identify appropriate activities for each phase of adoption) as they moved on to the next level. The wrap-up activity (Figure 146) was added to remind the player what the fundamental learning objective of the level had been.

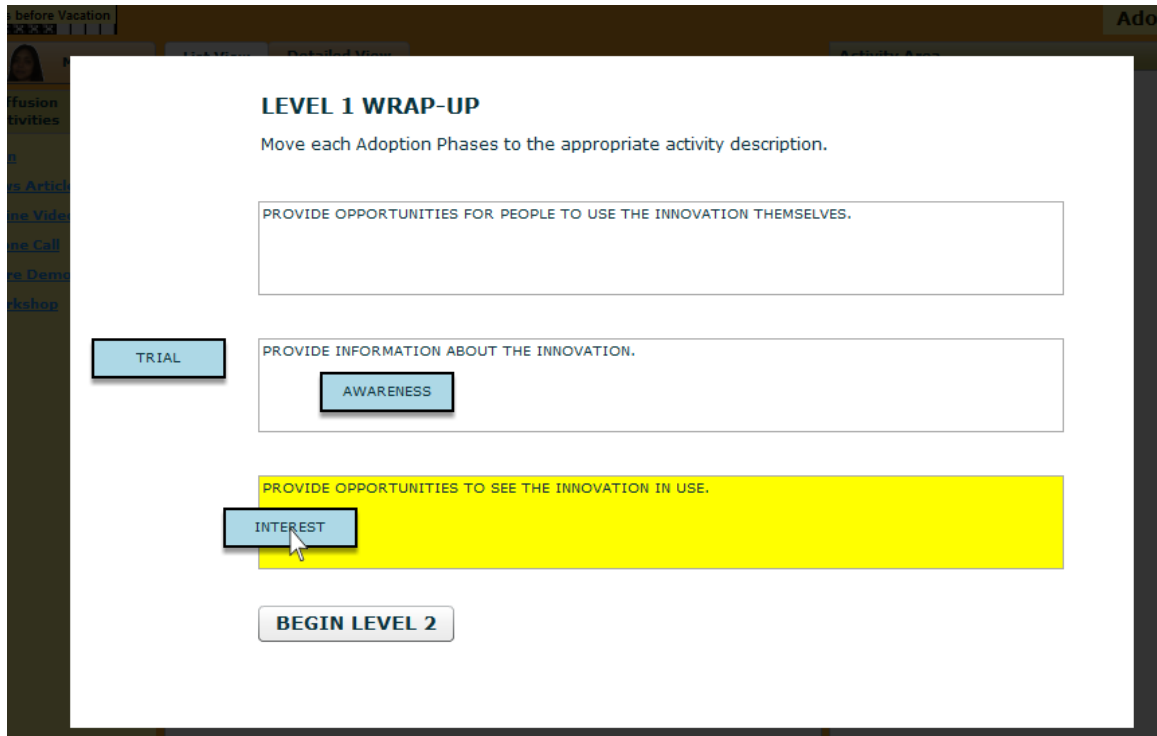


Figure 146. Screenshot of Level 1 Wrap-up Activity

6.2 (Round 6, Level 2)

The second level of the re-designed DSG includes three objectives which require the player moving a group of individuals through the phases of adoption of awareness, interest, and trial, to persuade them all to adopt an innovation. As with the previous level, each objective provides a new innovation, context, and diffusion activities, providing the player an opportunity to apply what they have learned to different situations.

To successfully complete the objectives in Level 2, players must understand the previous concept of Adoption Phases and how to select activities that are appropriate for an individual's current phase of adoption as well as the new concept of Adopter Types. Players are provided with the information they need to successfully complete the

objectives in Level 2 through an instructional video and an illustration of the mental model (Figure 147). While the instructional video provides detailed information about the characteristics of each of the five Adopter Types (Innovators, Early Adopter, Early Majority, Late Majority, and Laggards), the mental model reminds the player to focus on persuading the Early Adopters first by using what they learned in the previous lesson. Players should learn in Level 2 that the Early Adopters are highly respected in their community and will have much influence in persuading others to adopt the innovation. Consistent with the 4C/ID Model, the supportive information from both Level 1 and Level 2 is accessible by the player at any time during gameplay.

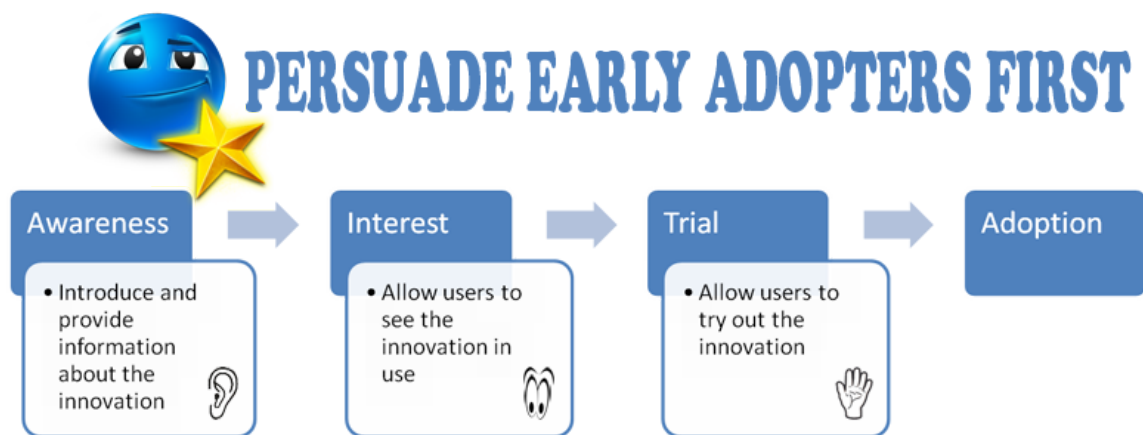


Figure 147. Mental model needed for players to complete the objectives in Level 2

6.2.1 (Round 6, Level 2, Objective 1)

The first objective of Level 2 requires the player to persuade multiple people to adopt an innovation: “Your objective is to persuade the Team Leaders of each of the 6 sales teams at Hoosier Sales Inc. to implement a new rewards plan. The rewards plan provides sales representatives with rewards for meeting specified sales goals.”

Before beginning the level, the player is provided with an instructional video which describes the characteristics of Adopter Types and explains the high level of impact that Early Adopters can have in speeding up the diffusion of innovations throughout a system.

While the previous objectives provided descriptions of the people the player is attempting to persuade at no cost (in game weeks), this level introduces the “Get Personal Info” Information Activity which requires the player to spend a week to get a description of three individuals at a time. The requirement to spend time getting to know the people in the system did not exist in prior objectives because the concept of Adopter Types had not been introduced and the personal information provided on the single individual the player was charged with persuading was of little help. In contrast, Level 2 requires the ability of players to classify several individuals into Adopter Types based on characteristics provided in their personal information. The first objective of Level 2, as the worked-out example, forces players to get personal information on all individuals before they are allowed to use any diffusion activities.

Once the player has gotten all personal information, they are forced to complete a Sort People activity similar to the Sort Activities activity found in Level 1. However, instead of sorting diffusion activities into appropriate categories of Adoption Phases, players must sort individuals into appropriate categories of Adopter Type (Figure 148). In the Sort People activity, the player can review the characteristics which are typical of each Adopter Type by rolling over the corresponding “About..” link.

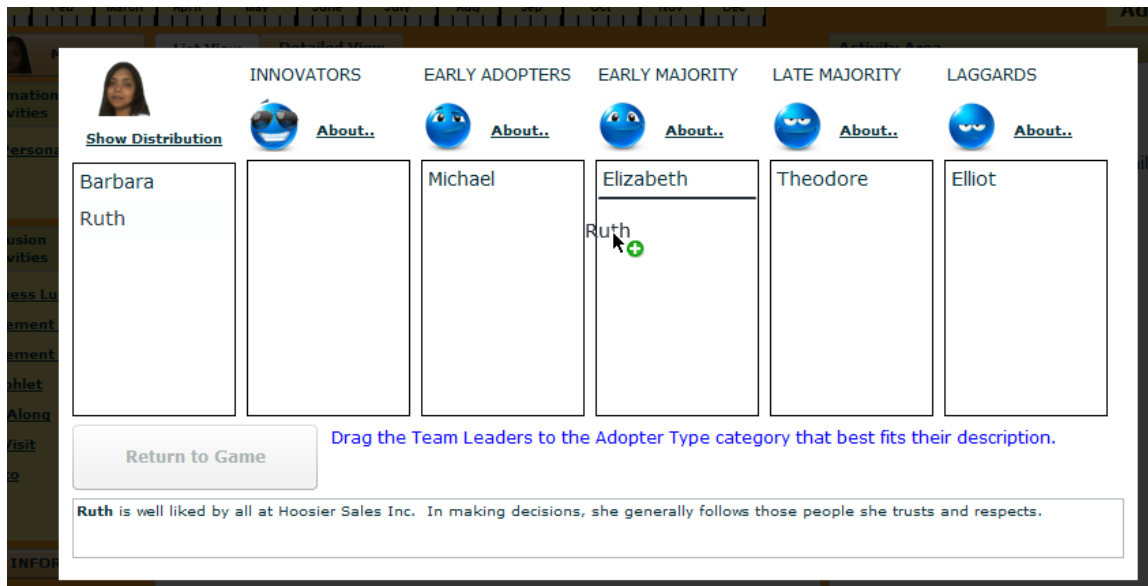


Figure 148. Sort People activity in Level 2, Objective 1

Upon getting personal information on each individual, a blue information icon appears next to each individual's name (Figure 149). When the player moves their mouse over this icon, they can view the personal information of the individual. This is consistent in all objectives in the re-designed DSG as well as with the original DSG. In this objective an additional roll-over icon is used. Upon successful completion of the Sort People activity, an orange Adopter Type icon is provided which the player may mouse-over to review the individual's Adopter Type (Figure 149). The "Detailed View" tab provides both the personal information and the Adopter Type without the need to mouse over icons.

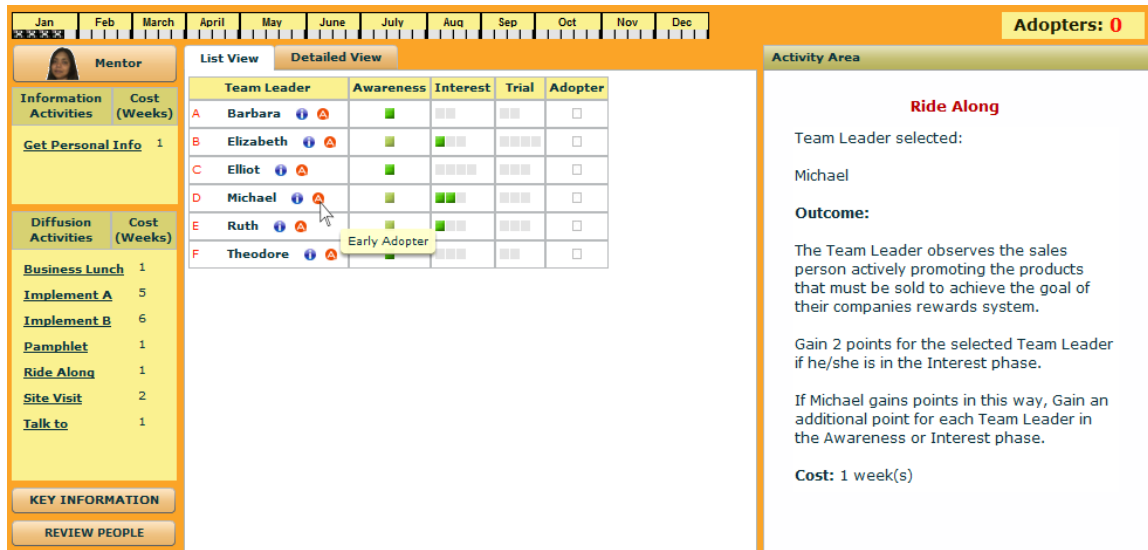


Figure 149. Screenshot of Level 2, Objective 1 while mousing-over the Adopter Type icon

In previous levels, all activities required the selection of a single individual. In this level, players are introduced to activities, such as “Business Lunch”, which require the selection of multiple individuals and others, such as “Pamphlet”, which include all individuals in the system.

Because this objective is the worked-out example of Level 2, the player is forced to use diffusion activities which include Michael, the only Early Adopter, until Michael has adopted the innovation. Furthermore, the activities chosen must be appropriate for Michael’s current phase of adoption, regardless of the phase of adoption of other individuals selected for the activity. When the player attempts to omit Michael (before he has adopted) in diffusion activities, or when the activity chosen is not appropriate for Michael’s current phase of adoption, the player is not allowed to complete the activity and mini-messages with corrective feedback are provided. For example, the mini-message in Figure 150 appears when the activity selected (Business Lunch) does not

match with Michael’s current phase of adoption (Interest). The mini-message in Figure 150 is followed immediately by another mini-message which states: “To do this, you must do more than just target an Early Adopter. You must also select an activity appropriate for the Early Adopter’s current phase of adoption.” Once Michael has adopted the innovation, the player is given the ability to select any individuals and any diffusion activities to persuade the remaining members to adopt the innovation.

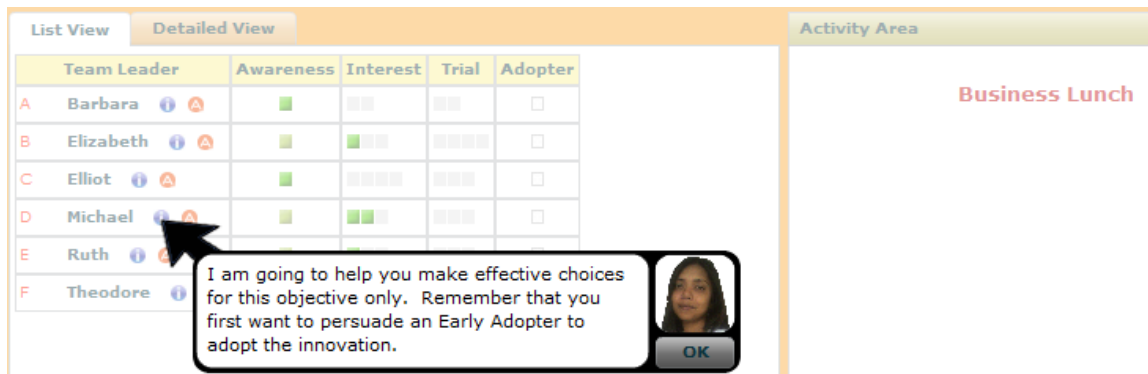


Figure 150. Corrective feedback provided in Level 2, Objective 1 via a mini-message

In this level and all subsequent levels, including Early Adopters in activities with others has positive effects on the rate of innovation diffusion throughout the system. Additionally, many activities are more effective once an Early Adopter has adopted, regardless of whether or not they are included in the activity. Lastly, some activities require the selection of an Adopter who will demonstrate the use of the innovation to others. If an Early Adopter is selected as the Adopter to give the demonstration, the impact on others will be much higher than if another person (especially a Late Majority or Laggard) leads the demonstration.

6.2.2 (*Round 6, Level 2, Objective 2*)

The second objective of Level 2 charges the player with the task of persuading 12 doctors at Mercy Medical Center to begin using a new angioplasty procedure that has lower risks to patients than the current procedure being used. The supportive information (instructional videos and mental model) from the current and previous levels remain available to the player. As prescribed by the 4C/ID Model, subsequent objectives in Level 2 provide the player with less instructional support. In this objective, there are fewer mini-messages providing guidance from the mentor and the Sort People activity is provided initially only as an option — not a requirement. If the player omits both the Early Adopters in this level three times before having persuaded one of them to adopt, they are then forced to complete the Sort People activity. Just as in the previous objective, upon completion of the Sort People activity, the Adopter Type of each individual is provided through the Adopter Type icons next to each individual's name.

6.2.3 (*Round 6, Level 2, Objective 3*)

The beginning of each objective starts with the game mentor providing the player with an introductory message, their objective, and lessons in the form of instructional videos for the current and previous levels. A screenshot of the “Objectives” section of this Mentor Panel is provided in Figure 151 and details the current objective and the player's progress through the entire game. Notice, in this case, the player is beginning Objective 3 of Lesson 2. Also notice the player has the ability to mouse-over and review the completed objectives. By pressing the “Mentor” button which appears in each objective at the top left of the screen (Figure 151), the player may return to this screen at

any time during the game to review messages (including all mini-messages) that were provided during the objective, the current and past objective descriptions, and the instructional videos for each of the levels that have been completed or initiated.

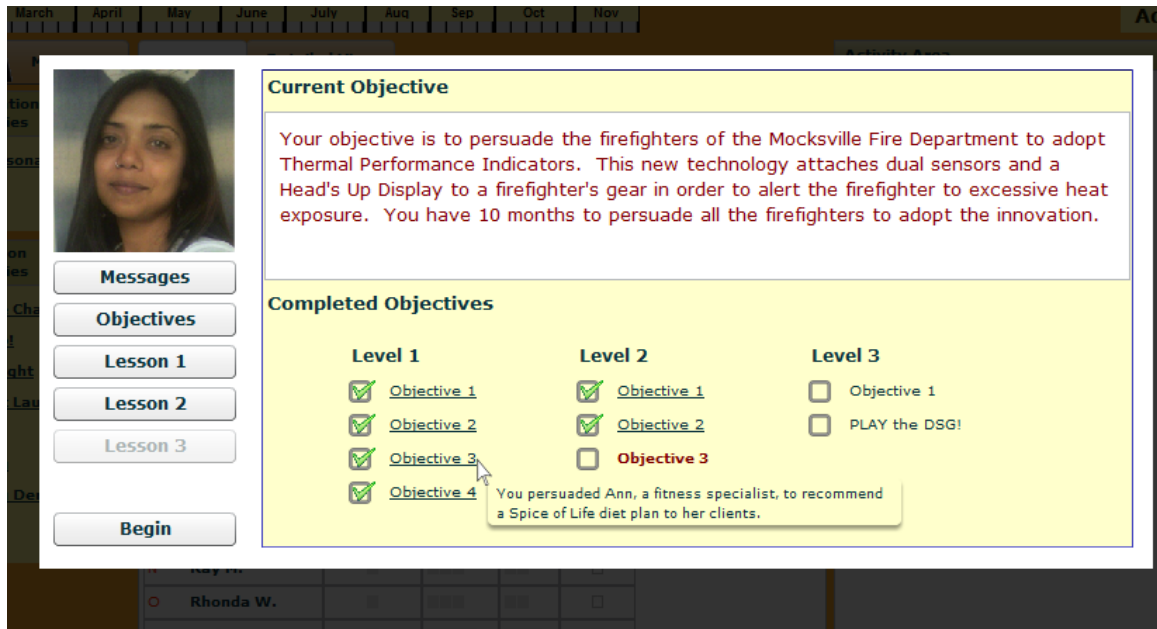


Figure 151. Objectives screen of the Mentor Window as seen in Level 2, Objective 3

In this objective, the player has more individuals (18 firefighters) to persuade than in any previous objective. The player has seven diffusion activities which are all different than any of the activities presented in prior objectives. Because this is the last objective of lesson 1, the player is provided no instructional support except for the supportive information (the instructional videos in this case) which has been persistent throughout the level.

6.2.W (Round 6, Level 2, Wrap-up)

A Level 2 wrap-up activity similar to the one used in Level 1 was added for the player to complete after successfully completing all of the objectives in Level 2. The Level 2 wrap-up activity, designed as a review of Adopter Type characteristics, is shown in Figure 152.

Figure 152. Screenshot of Level 2 Wrap-up activity

6.3 (Round 6, Level 3)

The third level is comprised of only two objectives and requires the application of prior concepts (Adoption Phases introduced in Level 1 and Adopter Types introduced in Level 2) as well as the newly introduced concept of Social Networks. This concept is again introduced to the player through an instructional video and subsequently summarized through a mental model (Figure 153).

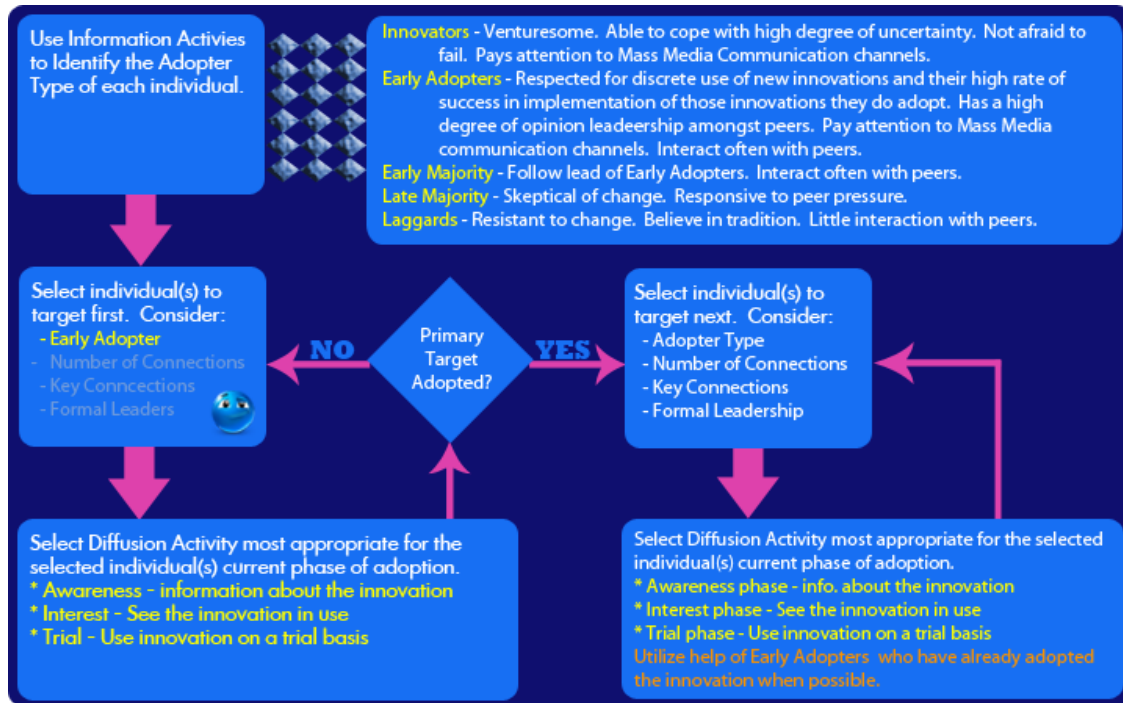


Figure 153. Mental model needed to complete the objectives of Level 3

6.3.1 (Round 6, Level 3, Objective 1)

The first objective of Level 3 was not designed as a worked-out example. This is largely due to the technical challenge of forcing the player to use a single strategy to solve an increasingly ill-defined problem and due to pressures on the developer/researcher to complete the study in a timely manner. While the player is not forced to use appropriate strategies, the mini-messages are used to provide guidance to the player. Also, poor game choices will likely result in the player having to repeat the objective until they improve their strategy and pass the objective.

Two additional Information Activities which each have a one-time cost of 1 week are available to players in this objective: *Social Groups* and *Restaurant Association*. The former provides the player with information about the informal networks in the game

(Figure 154). The latter provides information about the formal networks in the game (Figure 155).

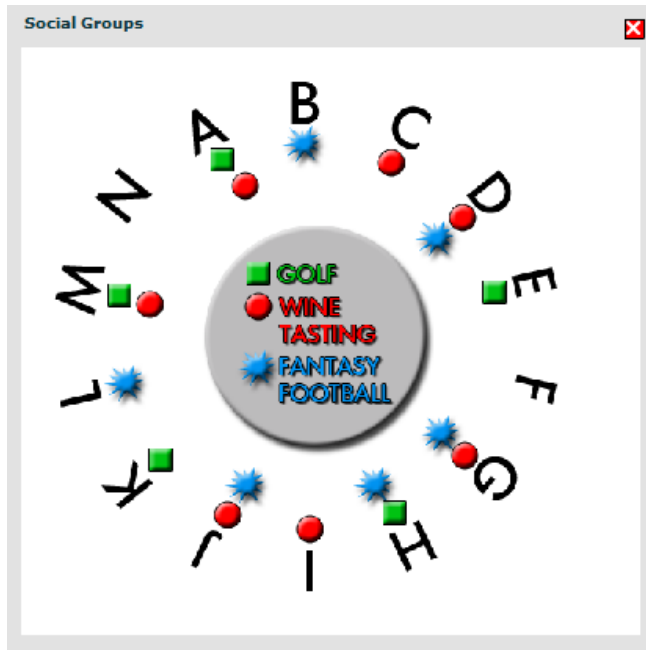


Figure 154. Social Groups (Informal Networks) that exist in Level 3, Objective 1

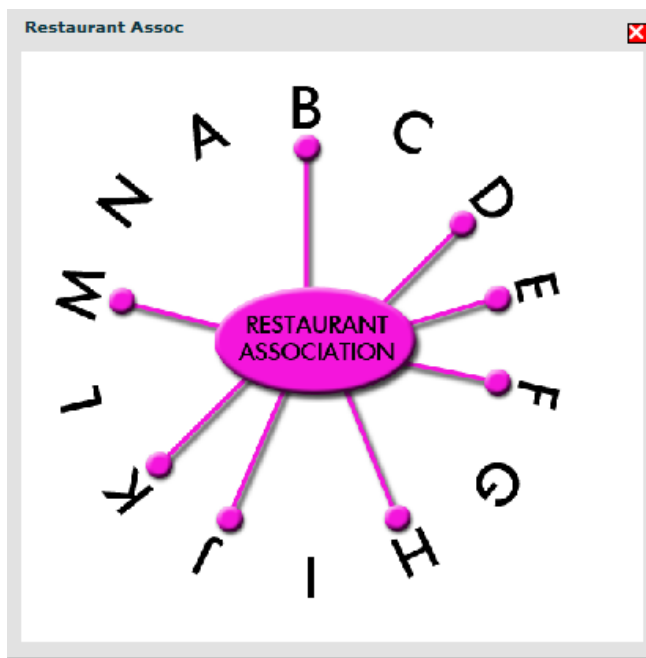


Figure 155. Restaurant Association (Formal Network) that exists in Level 3, Objective 1

Players need to use the information provided in these networks to help them decide who is most influential and who has the connections to other influential people so that they may target them for diffusion activities. By doing so, the player should be able to increase the rate at which the innovation is diffused throughout the system.

Once the player has retrieved the information related to the communication channels (formal and informal social networks) that exist in the social system, Network icons are made available to the player so that they may quickly consider this information when making game decisions without having to re-open the network diagrams (Figure 156). This makes it possible for the player to quickly see how many different groups each individual is in and what members of the system are connected. The Network icons can be moused-over for more information as demonstrated in Figure 156. In the “Detailed View”, each person’s social networks are listed above their Personal Information so that there is no need to mouse-over for additional information.

The screenshot displays a game interface for Level 3. At the top, a calendar shows months from February to August. On the right, a status bar indicates 'Adopters: 1'. The main area is divided into a left sidebar, a central table, and a right sidebar.

Left Sidebar: Contains sections for 'Mentor' (with a profile picture), 'Information Activities' (with a cost in weeks), and 'Diffusion Activities' (also with a cost in weeks). Under 'Information Activities', there are links for 'Get Personal Info' (cost 1), 'Social Groups' (cost 0), and 'Restaurant Assoc' (cost 0). Under 'Diffusion Activities', there are links for 'Exclusive Offer' (cost 3), 'Garden District' (cost 1), 'Home District' (cost 1), 'Lunch' (cost 1), 'Promo Cards' (cost 2), and 'TV Ad' (cost 2). A 'KEY INFORMATION' button is at the bottom.

Central Table: Titled 'List View' and 'Detailed View'. It lists 14 restaurants (A-N) with columns for 'Restaurant', 'Networks', 'Awareness', 'Interest', 'Trial', and 'Adopter'. Each row shows progress bars for these metrics. A tooltip 'Wine Tasting' is visible over the 'Networks' column for restaurant 'M' (Sushi Zone).

Right Sidebar: Titled 'Activity Area'. It features an 'Exclusive Offer' section with the text: 'Restaurant/Owners selected: Ray's (K), Mamma Mia (H), China Bistro (D)'. Below this is an 'Outcome' section stating: 'The reward cards are well received by customers. The owners who were willing to hand out the cards are pleased.' and 'Gain 1 point for those selected who are in the Interest or Trial phase.' At the bottom, it shows 'Cost: 3 week(s)' and '(Feedback Id: 85c)'.

Figure 156. Screenshot of Level 3 while mousing-over an informal network icon

6.3.2 (*Round 6, Level 3, Objective 2*)

The original DSG, which includes no instructional support, was used as the last objective of Level 3. This objective was described in detail in Chapter 3. The original DSG does not provide the player with Network icons nor guidance via mini-messages. The colors of the adoption points (squares) in the last objective of the re-designed DSG (the original DSG) differ from those in the previous objectives of the re-designed DSG. In the former, the squares (representing adoption points) earned in previous turns are red (Figure 5). In the latter, the squares earned in previous turns are a light shade of green. In both, the squares earned in the current turn are bright green. The reason the author changed the color of squares earned in previous turns from red to green was discussed in 2.1.1.F.

The final objective of the re-designed game is built on some concepts which were not introduced in the training, such as the concepts of formal leaders and gatekeepers. However, the most fundamental concepts of the Diffusion of Innovations theory which were introduced in the previous objectives (Adoption Phases, Adopter Types, and Social Networks) are still critical in increasing the rate of adoption in the final objective.

Unlike the previous objectives which require the player to persuade all people in the system, the final objective is to persuade as many people as possible to adopt the innovation. This is due to the high level of difficulty in the final objective. Instead of making modifications to the final objective, the author explained these differences to players as they began the final objective to avoid confusion.

Round 6 Findings

In the 6th and final round of formative research, 4 participants played the re-designed DSG as it existed in its final state at the end of the study and were the first to play through the third and final level of the game.

Much of the data collected in the final round were consistent with what was learned from participants in the previous rounds. Participants continued to make comments related to where they believed the game diverged from reality. Participant 16 doubted the effectiveness of giving a person who is not yet interested in the innovation a research report to read. In the third objective of Level 1, the same participant questioned the effectiveness of using an infomercial to raise awareness. When the activity was successful, the participant reflected “...but I wonder how many people it would really work with in real life because most people I know turn them off immediately.”

The time spent playing the game in Round 6 ranged from 153 to 306 minutes. Despite the amount of time required to play, participants had a positive reaction to the game as a whole. Participant 17 said “I enjoyed the experience. I especially like the training module; [the objectives leading up to the original game]. It felt more user-friendly and appealing.” Participant 19 said “the task was challenging to me and captured my attention throughout. The quick pace, immediate rewards through sound effects, colors, and [adoption points] was engaging.” Later, the same participant said “I do find it interesting, it’s just that I’m probably not doing it systematically and that’s kind of frustrating... but yes, it is fascinating... I’m learning how complex it is to influence people.” Participant 18 expressed a simpler feeling of enjoyment by saying “I enjoyed watching the boxes fill across the screen when I tried an action.”

Some of the game elements that players found enjoyable existed in the original DSG. For example, Participant 19 said “The task was challenging for me and captured my attention throughout. The quick paced immediate rewards through sound effects, colors, and tick marks was engaging.” Participant 18 stated “I enjoyed watching the boxes fill across the screen when I tried an action.... I liked seeing the photographs for the characters when I got their personal information.” However, participant comments suggested that the training levels of the game which include all of the additional instructional elements were more enjoyable than the original DSG. For example, Participant 17 said “I think you have a good start. I think the first part (the training) was much better than the last part. The last part (the school) was boring, confusing, and did not provide the satisfaction that it should have.”

The appeal of the instructional video to Round 6 participants was mixed. Participant 17 stated that “the training [video] was well designed and not too long” and “I like the pictures of the little smiley faces.” However, participant 18 was more critical of the instructional videos, stating:

“The first video was useful in laying out the theory and its parts. The second video was fairly useful, but too long. The third video did not help me at all, except to indicate that the next module(s) would incorporate formal and informal networks. This could have been because the video was too long, because the text on the screen was too small, because the screen was too full of text and images, because I was tired by then, and/or because the screen showed a confusing diagram that would have taken too much time to decipher (when I really just wanted to try it out and learn through that experience).”

The Probability Spinner was well received. Round 6 participants appeared to understand how the Probability Spinner worked and used the information provided to make good activity selections. Participant 17 said “It’s nice that you give the [Probability Spinner]” and expressed a desire to have the Probability Spinner in more of the objectives.

Participant 18 stated during gameplay that “the spinning wheel was very helpful to explain at least the chances of each [activity] working.” In the subsequent interview, the same participant noted “I liked the spinning wheel that showed whether an activity worked.”

As did previous participants, Round 6 participants gave positive comments about the sorting activities. For example, participant 17 stated that “I like that it lets you sort... I like that the graphic organizer [shows the expected distribution] and tells you if you are right or wrong” and “Although it did frustrate me, I kind of like challenges.” Participant 18 suggested that the sorting activities should be available in all objectives so players can sort people regardless of whether corrective feedback is provided or not.

Players’ perceptions on the mini-messages were mixed as well. Participant 17 stated that “It might be nice to have different people offer advice as when you keep seeing the same person your mind might be tempted to start ignoring them even if you don’t mean to. The virtual mentor was nice though, and I appreciated her.” Participant 18 noted early in her gameplay “So I kind of find the instructions quite helpful now...” and later in the interview noted that “the content [of the messages] was relevant and useful.”

Likewise, participants had different reactions to the task of getting personal information on each character. Participant 17 reflected that they liked the “Get Personal Info” activity because “if you do not know your audience it’s not going to help... I think it is worth the time cost to figure out who you want to spend time with. Otherwise, you might be wasting your time.” Participant 18, on the other hand, did not like having to get personal information from the participants only three or five at a time saying “it felt tedious to me.”

Round 6 participants noted a few elements of the game that were visually appealing which were also mentioned several times by previous participants. Almost all comments made about the pictures of characters in the game and the blue faces used to represent adopter types were positive. Participant 18, for example, said “I liked seeing the photographs for the characters when I got their personal information” and Participant 17 said “I like the pictures of the little [blue] smiley faces” when they appeared in the game.

Despite the many positive comments made about the game, several observations and participant comments revealed aspects of the game that needed to be improved. If these issues, which are discussed later in this section, are addressed the learning outcomes and game performance discussed next would likely be greater.

The pre- and post-test scores of the four Round 6 participants are provided in Table 15. These participants played through all three levels and so were expected to learn everything that was assessed in the pre- and post-test. Therefore, the pre- and post-test score was calculated by summing the scores from all three rows of the grading rubric (see Appendix G) for a maximum score of 6 points. Because the entire rubric was relevant to what the participants were supposed to learn, there was no need to calculate adjusted scores.

Table 15:

Round 6 Scores of Pre-/Post-tests

Participant	Pre-test	Post-test	Improvement
17	0	4	4
18	4	6	2
19	2	4	2
20	2	6	4

The mean post-test score of 83% (5 out of 6 possible) was a 50% improvement over the mean pre-test score of 33% (2 out of 6 possible). This 50% improvement provides some evidence that playing the game results in learning the diffusion of innovations concepts that are being tested.

In addition to the pre- and post-test scores, players' game performance on the last objective of Level 3 (provided in Table 16) further suggests that players are learning to effectively apply the diffusion strategies they have learned. This final objective is the same as the original DSG. Game performance was calculated based on each player's total number of adopters at the end of the game as well as a closeness-to-adoption score.

Table 16:

Round 6 Game Performance on Final Objective

Participant	Number of Adopters (22 possible)	Closeness to Adoption (24 possible)
17	5	13.4
18	9	16.4
19	5	12.0
20	7	12.2

Because two of the 24 staff members (the janitor and the secretary) in the final objective cannot become adopters, the maximum number of adopters possible in a single game is 22. The ratio of adoption points awarded (filled in squares for an individual) to the adoption points possible (total squares for an individual) was used as a closeness-to-adoption score for each individual that ranged from 0 (no adoption points awarded) to 1 (all possible adoption points awarded). The individual closeness-to-adoption scores were then summed for an entire game closeness-to-adoption score which fell between 0 (no adoption points awarded for any of the staff members) and 24 (all possible adoption points awarded for each of the 24 staff members).

Several usability and design issues for each of the three levels were revealed in the last round of data collection. Further improvements to the game and the instructional content in the game would likely further increase game performance and player learning. As with every round of Formative Research completed, the issues that surfaced in Round 6 and the potential solutions to those issues were documented (see Appendix I for a full list). However, due to lack of time and resources, this was the last round of Formative Research

completed in the study so none of the solutions were implemented. The solutions to the most significant known remaining issues are discussed below.

The first issue that is yet to be addressed is the negative effects of having a large amount of textual information in the game. Reaction to the amount of text was typified by Participant 18 who said “There was a lot of textual information. When possible, the use of visuals would make the interface more attractive.” Likewise, Participant 17 said “I would like it to not be all text based and be more visual” and also “One problem is that this is a text based game which in itself is just generally unappealing because it is difficult to hold people’s interest with only text.” Besides the negative effect that large amounts of text has on appeal, the unrealistic expectation for players to read the large amount of information provided may diminish learning. All participants in the study appeared to pick and choose which textual information to attend to and which to ignore or skim over. In all game sessions, players missed information that would have helped them avoid frustrations and pitfalls they experienced in the game. A common instance of players in Round 6 not reading information carefully was in the text related to the “Dr. Exchange” activity in the second objective of Level 2. The description of the “Dr. Exchange” activity stated “You select ONE doctor to switch roles for a day with a doctor from Mercy's partner hospital who has been using the new procedure. This will allow all the doctors, EXCEPT for the one selected, to watch the procedure performed.” Despite several sources of information (the activity description of the “Dr. Exchange” activity, feedback messages related to the outcomes of the activity, and mini-messages highlighting the nuances of the activity), players continued to misuse the activity by targeting individuals for that activity whom they were hoping to persuade. Participant 20 expressed confusion over this activity after using it unsuccessfully with a character in the game by saying “Ay... that doesn’t make

sense. If he is sent how can he not be aware?” Solutions to the issue of overwhelming players with too much text could involve providing information more concisely, omitting information that is not absolutely necessary to the player, implementing non-textual methods of providing the player with the same information, or completely redesigning the game in such a way that reading text is not such an integral part of the gameplay.

Another issue which has a much more straightforward solution relates to the trouble some players had in correctly identifying the current phase of adoption of an individual in the game. Consider the scenario depicted in Figure 157. When a character has all the adoption points in a particular phase of adoption (all squares under Interest are green) but no adoption points in the next phase of adoption (all squares under Trial are gray), then it is unclear to many players which phase of adoption the individual is in. Figure 157 shows the first attempt that was made to address this issue. By highlighting the heading for the character’s current phase of adoption (Trial), the character’s current phase of adoption was made clearer.

Student	Awareness	Interest	Trial	Adopter
David	■	■■■	■■■	□

Figure 157. Screenshot of Level 3 when character has just entered the Trial Phase

This solution was implemented only in the first two objectives for two reasons. First, the original DSG which the player would later have to play does not provide this signal to the player, so phasing out this signal prior to the final objective was needed. Secondly, the objectives after Level 1 involve multiple characters which are usually in different phases of adoption and so it would not be possible to highlight the headings in a

meaningful way for the player. A straightforward solution to this issue would be to highlight the appropriate cell of each character to indicate their current phase of adoption in all objectives, including the original DSG.

Two more issues were brought to light by Participant 19. Though these issues were not prevalent with all gameplay experiences, it is foreseeable that other players would have the same issues. Because these issues would likely have very negative effects on some players' game performance and understanding, solving the issues would be critical in further developing the re-designed version of the DSG.

The first of these critical issues involves the "Back" button of the browser the game resides in. As a browser-based game, any redirection from the game's URL will exit the game. In the case of the re-designed DSG, each objective is a separate file and therefore has a separate URL. If a player clicks the browser's "Back" button during an objective to attempt to go back to a different part of the objective, as Participant 19 did, the previous objective will be loaded into the browser because that was the user's previous URL. Solutions to this could involve automatic saves and/or the opening of the game within a browser window in which the "Back" button is disabled or removed.

The second critical issue was revealed when Participant 17 and Participant 19 expressed confusion about the different colored squares. Recall that initially the squares were gray (not completed), green (completed in the last turn), or red (completed in an earlier turn) and that players often interpreted red to be negative. Also recall that the red squares were replaced by faded green squares in the re-design of the DSG. This addressed the issue of players misinterpreting the red squares as being negative while players still benefitted from having the newest points be a different color than the previously earned points. For example, Participant 18 stated "It's nice that the most recent ones are a

different shade of green because right now I am certainly relying on that [to see who just earned points from the last activity I used].”

However, Participant 19’s asked during gameplay “Now I notice that the Awareness has a light green [square], so does that mean that he is not aware of it?” Another participant from a previous round had a slightly different misinterpretation of the green squares, believing that the faded green indicated that the interest of the character was beginning to fade. Participant 17 also had trouble understanding meaning of the colors. “I didn’t understand the different green colors for points until they were explained to me near the end of round three [when the researcher intervened]. Since I was guessing what they meant, I made some choices using an incorrect strategy.”

Despite some confusion with the meaning of the green and faded green squares, instances in which the colors confused players were less frequent and less disturbing than when red squares were also used. Participant 18 was confused by the red squares when they appeared in the last objective (the original DSG). Despite the researcher intervening prior to the objective to explain the meaning of the red squares, Participant 18 said in the interview “On the actual game, the red boxes to indicate older progress confused me after having seen the lighter green boxes in the tutorial (I thought it meant negative).”

How to Play the Re-Designed DSG

The final re-designed version of the DSG as it existed upon the completion of this study can be played at <http://www.indiana.edu/~simgame/research/training> for the indefinite future. Note that there are a few persistent bugs. The most critical of these bugs occurs in the third objective of level two where the diffusion activities occasionally do not appear. The work-around for this bug which was used with participants who encountered

it was to refresh the page. Another bug which still exists occurs in the first objective of level three where the social network icons are incorrectly displayed in the detail view. The work-around for this bug which was used with the final four participants who played through this objective was to interrupt their gameplay if they attempted to switch to the detailed view. All other known bugs are relatively minor and do not hinder gameplay.

Chapter 11: Results

In this chapter, the research questions of the study are answered, identifying ways in which the TSCL could have been more helpful in its application to the re-design of the DSG. To answer the research questions, the TSCL was judged on its *sufficiency*, *expendability*, and *adaptability* in its application to the redesign of the DSG. These criteria were described at the end of Chapter 4.

Answers to Research Question 1

The first research question which guided the study was:

- How could the TSCL have been more useful in re-designing the DSG to be effective and efficient to the players who participated in this study?

TSCL and the Effectiveness of the DSG

Sufficiency: This study revealed that the TSCL was insufficient in re-designing the DSG to be effective in meeting its learning objectives. The post-test scores (and the improvements from pre-test to post-test) provided evidence that learners who played the re-designed DSG successfully met most of the learning objectives. However, while the TSCL was in large part responsible for these positive results, several issues emerged as deterrents to learning which reveal insufficiencies with the TSCL in its application to the redesign of the DSG. The insufficiencies revealed include a lack of guidance on how to deliver information within a digital environment, a lack of guidance on how to overcome players' beliefs which are contradictory to the game and what is to be learned, and a deficiency of a requirement to use the TSCL within an ISD process. These three insufficiencies are discussed below.

(Insufficiency #1) First, while the TSCL provides guidance for **when** to deliver information (based on whether the information is supportive or procedural in nature), it does not provide guidance on **how** to deliver the information. The need for this guidance became evident when players ignored information that was presented to them or were not aware that information was available. The issue appeared to stem from how the information was presented to the player and how much competing information was being presented at the same time. Many strategies were used to resolve this recurrent problem when re-designing the DSG.

One strategy was to vary how the information was presented to players and how easily accessible the information remained to players. Some information was displayed on the screen at all times for players. Other information could be accessed quickly without breaking player emergence into the game via links and icons which could be moused over to display information. Pop-up windows may require players to leave the game space temporarily to access some information. Players may have the option to have the information displayed based on their preference. Though not used in the DSG, information could be provided externally from the game either through physical documentation (e.g., books, handouts, etc.) or through digital resources (e.g. websites, PDFs, etc.). The use of physical documentation would give players access to relevant information without competing for screen space. Similarly, if the player had dual monitors, the digital resources could provide players with information without forcing the player to leave the game. These options were avoided in redesigning the DSG because the designer does not expect the target audience (often students taking a university course online) to be working on a computer with dual monitors or to be able and willing to print the materials.

In re-designing the DSG, deciding how the information was presented to players and how easily accessible the information remained to players generally depended on the importance of the information, the frequency in which players need to access the information, or how previous attempts of providing the information to players succeeded or failed. For example, the sort activity initially required players to click on the “View Activity Descriptions” link each time they wanted to read an activity description. This was cumbersome and interrupted the sort activity which the player was completing. In Round 4, the Sort Activities activity was modified to allow players to access the activity descriptions by mousing over the corresponding activities (4.1.2.C). This method allowed players quick access to information they needed to refer to frequently without breaking their train of thought or their emersion into the Sort Activities activity.

Another instance in which information frequently needed by players was provided in a quickly accessible way was in the use of Adopter Type icons (4.2.1.P). These icons were made available after the player correctly completed the Sort People activity so that they could quickly identify the adopter type of each person in the game without having to re-open the Sort People activity. A further enhancement was identified which would have made the information even more accessible without requiring any more screen real-estate. The enhancement, which was not implemented due to time constraints, was to provide abbreviations of the Adopter Type (I, EA, EM, LM, or L) next to each person which could be viewed without the need to mouse over the Adopter Type icon.

A second strategy used to encourage players to attend to information provided in the re-designed DSG was to provide the information repeatedly to the player and/or use multiple methods to introduce the learner to content. For example, the information related to which type of activities are appropriate for each adoption phase was provided in many ways, including the Instructional Video (1.1.1.E), the Key Information button (5.2.1.A),

the Sort Activities activity headings (2.1.2.H), the Activity Log (5.1.1.B), and the Adoption Phase headings (3.1.1.D). Likewise, many attempts were made to inform player that using activities repeatedly could be effective, including repeated mini-messages (1.1.2.E, Figure 78) and text within the Probability Spinner (Figure 56). Adding an activity at the end of each task class to review and summarize the key concepts that were learned (e.g. 5.1.W, 5.2.W) was another attempt at providing information repeatedly and in a different way than it was presented before.

Another strategy for getting players to attend to information included emphasizing key information in order to increase the probability that players will attend to the information. For example, important text within mini-messages was bolded (2.1.1.D), color was used to draw attention to some information (2.1.2.D), and visuals were used to enhance information that was not being attended to (4.1.2.D).

A final strategy for getting players to attend to information that was used in the re-design of the DSG was to rely less on text for conveying information and more on visual elements, animation, and interactive elements. For example, the images of the eyes, ear, and hand (2.1.2.D) were used to convey meaning to the players through iconic elements; the Probability Spinner (3.1.2.B) was used to convey meaning to the player through animated elements; and the sorting activities (4.1.2.C and 4.2.1.K) and wrap-up activities (5.1.W, 5.2.W) were used to convey meaning to the player through interactive elements.

Every piece of information in the game (e.g. activity descriptions, number of adopters, current phase of adoption, outcomes from using activities, instructional support, etc.) had to be provided to the player in one or more ways. How to best provide information so that players attend to it was a constant negotiation in designing and improving the re-designed DSG which the TSCL did not provide guidance for.

(Insufficiency #2) The TSCL appeared to be insufficient for re-designing the DSG due to its lack of guidance related to concepts which learners have a difficult time accepting. Two issues emerged in the re-design of the DSG in which providing supportive information or procedural information was insufficient in changing players' beliefs or behaviors. The first issue related to the stochastic nature of the game. Players often made premature conclusions about the effectiveness of a diffusion activity based on one or two unfortunate outcomes. This tendency to over generalize hindered the performance of players and distracted them from the learning objectives. The second issue related to discrepancies between the players own beliefs and how the simulation worked. Players often were unwilling to use strategies that did not align with their own beliefs (which were sometimes based on prior real-world experience). For example, several participants were reluctant to use research reports, infomercials, and reality television as diffusion activities because of their own beliefs as to the ineffectiveness of these activities. Similarly, almost all of the early participants of the study were unwilling to repeat activities due to their belief that using the same activity more than once would be ineffective.

In the DSG, several strategies were used to overcome players' strongly held beliefs when they did not align with the game. For example, to address players' difficulty in understanding the stochastic nature of the game, game elements were added to correct misconceptions that commonly occur during gameplay due to premature conclusions made by players based on unfortunate outcomes. Specifically, the Probability Graph was added to make the chance element of the game transparent to the player (2.1.2.C). Similarly, the Activity Log was added to make it clear to players that the element of chance sometimes led to a disparity between the appropriateness of an activity and the effectiveness its outcome (5.1.1.B).

The TSCL provided insufficient guidance for addressing players strongly held beliefs that were inconsistent with the gameplay and/or with the content being learned. Because the DSG, like many educational games, provides players with learning tasks which simulate tasks in the real world, it may have been helpful for the TSCL to have provided guidance on how to deal with instances when the game does not simulate the real world as closely as players expect, or when players beliefs are inconsistent with the simulation and/or the real-world.

(Insufficiency #3) The TSCL was also insufficient in that it did not **require** an iterative process of design and development. While the TSCL is a design theory—not a development process—van Merriënboer suggests that the TSCL be done within an ISD context (see the “TSCL within an ISD Context” section of Chapter 2). The iterative design and development process used in this study was essential in re-designing the DSG to be effective for learning. Requiring, instead of suggesting, that the TSCL be used within an ISD process would have been appropriate for the re-design of the DSG because, as a digital game, bugs and usability issues sometimes completely suspended all desired learning from occurring. This was evident during Round 1 where many bugs and usability issues impeded the progress of players and required the designer to interrupt gameplay to help players continue.

Embedding the TSCL within an ISD process also increased the effectiveness of the re-designed DSG because it allowed for the designer to address emergent concerns. The strategies used regularly in re-designing the DSG included modifying or removing game elements and game mechanics that were misunderstood by the learner (e.g. 2.1.1.F, 2.1.1.G, 5.1.1.A, 5.1.1.B), improving quality of instructional content (e.g. 3.1.1.B, 3.1.1.C), tweaking the game to have the appropriate level of challenge (e.g. 3.1.4, 5.1.3.A, 5.1.4.A, 4.1.4).

While a conclusion made from this study is that the TSCL was insufficient in re-designing the DSG to effectively meet its learning objectives, the study demonstrated that the TSCL was useful in providing a fundamental structure for designing the DSG to support complex learning. While supplemental strategies were needed to enhance learning and address deterrents to learning that were revealed during the study, the TSCL provided the structure which informed the initial design of the game. Whereas the supplemental strategies focused on the more detailed aspects of the game and of learning, the TSCL provided an overarching ID strategy and therefore was the primary guide in how the instruction in the overall game was broadly designed.

Expendability: The second approach used to judge the TSCL was to determine which steps of the TSCL were expendable in re-designing the DSG. In this study, were any of the steps of the TSCL expendable? To make this determination, the designer reflected on how much each step was relied on during the study.

The first two steps (designing learning tasks, sequencing learning tasks) were fundamental in designing the game. The objectives, levels, scaffolding, simple-to-complex sequencing of learning tasks, and task variation, which resulted from following the first two steps of the TSCL were arguably the most contributing elements both to the design of the game as well as to the learning gains that resulted from playing the game. Without following these fundamental steps of the TSCL, it would not be possible to claim that the TSCL was used in the design of the DSG.

Step 3 (setting performance objectives) also was an indispensable step in designing the DSG. Setting performance objectives **for each game objective** was necessary in determining when players should be able to progress to the next objective. Game objectives were tweaked to adjust their difficulty level throughout the study to ensure an appropriate amount of challenge. Setting performance objectives **for each level** was

necessary in determining when players should be able to progress to the next level. The number of objectives and the rate at which instructional support was faded was adjusted throughout the study to ensure players would reach the intended performance objectives.

Step 4 (designing supportive information) was also relied on heavily to provide the learner with the supportive information needed to complete the objectives of each level. In this study, the instructional materials used to provide the learner with the supportive information were developed from scratch.

Step 5 (analyzing cognitive strategies) was used in this study to a lesser extent due to a lack of proficient task performers to observe. One cognitive strategy that was taken from “slightly” proficient players of the DSG was the activity of categorizing people into different categories based on their opinion leadership and/or their openness to change. This strategy aligned well with the concept of Adopter Types which was to be learned in Level 2 and led to the creation of the Sort People activity. The sorting strategy was also transferred to the concept of Adoption Phases (categorizing activities into the Adoption Phases they are most appropriate for) which was to be learned in Level 1.

Step 6 (analyzing mental models) was also used to a lesser extent than many of the other steps. However, neglecting the rigorous use of the step may have been detrimental to the design of the DSG to promote learning. In this study, the author designed the mental models for each level based on his own understanding of how to best apply the Diffusion of Innovations theory to facilitate the diffusion of an innovation throughout a system. Though the author’s understanding came from reading the Diffusion of Innovations theory which the game was designed to teach and from studying the gameplay patterns of successful and unsuccessful gameplays, the mental models used by players were not analyzed. Additionally, the mental models provided to learners for the re-

designed DSG were never modified. The mental model for Level 3, in particular, could have been improved to be more useful to players.

Step 7 (designing procedural information) was a step of the TSCL that was relied on heavily in re-designing the DSG. This is especially true because the procedural information included not only the procedural information related to how to effectively apply the Diffusion of Innovations theory (the content to be learned), but also the procedural information related to how to play the game.

Step 8 (analyzing cognitive rules) and Step 9 (analyzing prerequisite knowledge) were not used at all in this study. Though the designer did create the procedural information from scratch, the designer did no analysis to prepare for creating procedural information. Instead, the designer relied on his pre-existing knowledge of the Diffusion of Innovations theory and of how the original DSG was played. One reason that Step 8 and Step 9 were ignored was that the procedural information relevant to the theory was simple in nature. Unlike more complex procedural information which consists of multiple steps that must be taken in a particular sequence (e.g. solving a quadratic equation), the procedural information in the DSG was very simple (e.g. selecting the diffusion activity that would be effective for a particular individual given their current phase of adoption, selecting individuals who are most influential or well connected).

Step 10 (designing part-task practice) was used in this study to provide learners the opportunity to practice classifying activities based on what Adoption Phase they are most appropriate for (Sort Activities activity) and to practice classifying people into Adopter Types based on their personal characteristics.

Note that steps 5, 6, 8, and 9 are prescriptions of the TSCL which are meant to be used optionally based on the unique nature of the supportive information and procedural information that is needed for learning the intended content. Step 10, though useful in this

study, is also prescribed as an optional step depending on the need for learners to develop skills at a high level of automaticity.

In conclusion, Step 8 and Step 9 were the only steps of the TSCL which were expendable in re-designing the DSG. However, the exclusion of these two steps is not unusual because many of the steps of the TSCL are provided optionally based on the content and skills that are to be learned.

Adaptability: The steps of the TSCL are extremely flexible. Many of the steps are optional. Also, they are meant to be followed non-sequentially and in an iterative manner. This flexibility resulted in the TSCL fitting well with the iterative design process the author normally uses when designing and developing games. Therefore, this study revealed that few adaptations were needed to the TSCL in its application to the re-design of the DSG.

The only adaptation to the TSCL identified that may have improved its effectiveness in re-designing the DSG was to provide an initial learning task prior to any supportive information. For instance, providing supportive information after the player has had time to learn to play the game instead of simultaneously (Round 2 Reflections) may have supported complex learning by reducing the initial cognitive load experienced by players. Additionally, providing the player the opportunity to complete the task prior to giving instruction would allow learners to immediately begin gameplay and also provide them with an experience to reflect back on when the supportive information is introduced.

The strategy of providing an initial learning task prior to supportive information was not implemented in this study because it was contradictory to the TSCL prescription of providing supportive information prior to learning tasks. However, the study revealed that several players felt overwhelmed with the amount of information provided in the first objective and that they did not clearly see the connection between the supportive

information provided prior to gameplay (the first instructional video) and the learning tasks provided in the game. Examples of this sentiment came from Participant 5 who stated “I think I was more focused on learning the game than on the information that was supposed to be learned” and Participant 4 who said “I think that by this point, because it was 3 minutes into the video and I’m learning a new process, it was just so much information at once, that by the time I got here, I was hearing it but was not processing what was going on.” The concern that players were missing the most important information to be learned due to their focus on learning the basic game mechanics needed to play the game led to the implementation of wrap-up activities (5.1.W.A). However, this attempt at addressing the issue was more of a band-aide approach to ensuring that players learn what was intended from playing Level 1 in case the gameplay itself failed.

Additional justification for providing an initial learning task prior to supportive information can be found by considering other ID theories. Recall from Chapter 2: Literature Review that one of the five principles provided by David Merrill in his *First Principles of Instruction* is Activation (see Figure 1). The Activation principle states that learning is promoted when learners’ relevant previous experience is activated (Merrill, 2002). One of the corollaries Merrill provides to this principle which relates to providing learners with new experiences states “Learning is promoted when learners are provided relevant experience that can be used as a foundation for the new knowledge” (Merrill, 2002, p. 46).

TSCL and the Efficiency of the DSG (Research Question 1 Continued)

As discussed in the last section of Chapter 3, the author believes the effectiveness of an educational game in enabling players to meet the intended learning objectives is of more importance than the appeal of the game which in turn is more important than the

efficiency of the game. Therefore, the criterion of efficiency was given the least consideration during the study.

Consider the last four participants of the study who played through the entire re-designed DSG. For these participants, the mean post-test score of 83% was a 50% improvement over the mean pre-test score of 33%. Given more iterations of design and development of the re-designed DSG would have likely improved the game and the instructional content in the game, further improving the effectiveness of the game in promoting learning.

However, these learning gains came at a price. The last four participants spent almost four hours, on average, playing through the entire re-designed DSG. Is this amount of time adequately efficient? This is a judgment that must be made by the learner or instructor. When asked in the interview whether the game was too long, almost all participants reported that they did not get bored with the game because it was challenging and engaging. In fact, the last four participants who played through the entire re-designed DSG were interested in playing the final objective again to see if they could get more adoptions than they did in their first attempt.

Because the TSCL requires the learner to complete a variety of holistic complex tasks, games developed following this ID theory will likely take a significant amount of time to play. However, as discovered in this study, learners may be willing to spend a great amount of time and effort to master the game as long as they find it sufficiently engaging. In this study, the TSCL appeared to be suitable for developing the DSG to be efficient when judged on the amount of time needed to complete the game vs. the amount of time learners are willing to spend playing the game.

Answers to Research Question 2

The second research question that guided the study was:

- How could the TSCL have been more useful in re-designing the DSG to be appealing to the players who participated in this study?

TSCL and the Appeal of the DSG (*Research Question 2*)

Sufficiency: This study revealed that the TSCL was helpful in re-designing the DSG to be appealing. From the very first round of the study, participants reported that the game was engaging. The appeal of the game increased each round as the level of challenge was adjusted, the bugs and usability issues were addressed, and the instructional content was improved. For example, the number of weeks in each objective was frequently adjusted to ensure that players who made few or no mistakes in selecting appropriate people/activity pairs would successfully complete the objective; and players who made multiple mistakes in selecting people/activity pairs would fail the objective. Another example of the appeal of the game increasing throughout the study relates to improvements made to the Lesson 1 instructional video (3.1.1.B). The bugs and usability issues experienced by Round 1 participants were so great that the gameplay session had to be interrupted to help the player move past a point in the game in which they were unable to progress on their own.

Despite the TSCL being sufficient in re-designing the DSG to be appealing, the study revealed several strategies and game elements which further improved the appeal of the DSG which were not suggested by the TSCL. These strategies and game elements include: game elements which existed in the original DSG (e.g. pictures, points, sound associated with points, and challenge), embedded instruction that supports learning (e.g.

instructional videos, mini-messages, sorting activities, Activity Log, Probability Spinner, and wrap-up activities), usability improvements (e.g. 2.1.1.C, 3.1.1.A, 4.1.1.D, 4.1.2.C, 5.2.1.B), concise delivery of instruction (e.g. 4.1.1.B), details about the context of game and how far the player has progressed (e.g. 2.1.1.A, 2.1.1.B, 2.1.2.A, 4.1.1.A, 4.1.2.A), interactive elements (e.g. 3.1.2.A, 3.1.2.B, Round 2 Reflections), animation (e.g. 3.1.2.B, 4.1.2.F, Round 2 Reflections), visual elements to provide meaning instead of, or in addition to, textual information (e.g. 4.1.1.A, 4.1.2.A, Round 6 findings), providing methods for accessing different information based on the frequency the information needs to be accessed (Round 6 Reflections), and increasing player odds for positive outcome in chance elements (5.1.2.B).

Note that modifications to the game that were made to promote learning, or address concerns related to gameplay that hindered learning, were usually also helpful in promoting appeal. For example, the sorting activities were designed primarily to increase the DSG's effectiveness but were also found by participants to be appealing due to their interactive nature. Likewise, the Probability Spinner was introduced to increase the DSG's effectiveness but was also found by participants to be appealing due in part to it being animated.

The strategies and game elements that were used to enhance the appeal of the game beyond what the TSCL provided had varying degrees of appeal for different players. The degree to which players enjoyed each of the game elements was described throughout the Design Case (Chapters 5 through 11).

Expendability: The TSCL is focused on the how to create instructional design that is effective. Still, by providing instruction in an effective manner, the TSCL indirectly promoted the appeal of the DSG. Therefore, as described in the previous section (TSCL and the Effectiveness of the DSG), only Step 8 and Step 9 were expendable in re-designing

the DSG. Because Step 8 and Step 9 were not followed in this study, their potential impact on the effectiveness and appeal of the re-designed DSG was not explored.

Participant Demographics

The results from the surveys completed in the study provide some light on the demographics of the participants. All participants were graduate students in academic programs which offered a course in change management and/or diffusion of innovations. This is the primary audience for which the game was designed. However, the students had not yet taken the course and had no knowledge of the diffusion of innovations theory and no prior experience playing any version of the DSG. The subjects from Indiana University ($n=4$) participated in a face-to-face manner. The remaining subjects participated virtually via Adobe Connect from institutions including Florida State University ($n=9$), Walden University ($n=4$), Harvard University ($n=2$), and University of Maryland ($n=1$). Eleven of the participants were female. Nine were male.

Participants' experience in playing digital games varied widely and ranged from currently not playing games at all (often due to the demands of their academic programs) to playing 10 hours per week. Some participants stated that while currently they do not play games frequently, they had previously in their lives played 20 to 40 hours per week. The games played by participants were also very diverse. They included *Solitaire*, online poker, online checkers, *EverQuest*, *Farmville*, *Wheel of Fortune*, *Jeopardy*, *Medal of Honor*, *Wii Fit games*, *Need for Speed*, *Toy Story*, *Civilization*, *Tetris*, *Super Mario Brothers*, *Scrabble*, *World of Warcraft*, *Paper Mario*, *Star Wars*, *Star Craft*, *Myst*, *Diablo*, *Final Fantasy*, and *Legend of Zelda*.

Lastly, while no participants had any formal training on diffusing innovations, almost all reported one or more experiences in which they attempted to persuade an individual or a group of people to adopt an innovation. The experience may have been as

simple as attempting to persuade their parents to use Skype to communicate with them. Several participants who worked as teachers or trainers talked about getting their students, or other teachers and trainers, to adopt a new technology or a new methodology. Two participants discussed their experience of diffusing an innovation in the military. While one was charged with the task of getting the military to adopt radio jamming technology to prevent injuries from explosives, the other worked to convert the patrol system for military police to operate in zones.

The demographic information is being reported here to provide the reader with a general idea of who participated in the study. Because of the small number of participants in the study and because the demographic information was not directly relevant in answering the research questions, there was no attempt made to make comparisons between groups (such as males vs. females or gamers vs. non-gamers) in a rigorous manner.

Chapter 12: Findings: Summary Reflections

As part of the Formative Research methodology used in this study, after each round of design, development, and evaluation; reflections were made on how useful the TSCL was in re-designing the DSG and how it might be improved. These reflections are provided in Appendix K. Additional reflections which were made after the study was complete are provided in this chapter.

Summative Reflections

Once all rounds of Formative Research were complete, the researcher/designer reflected on how the 4C/ID Model and the TSCL supported the re-design of the DSG in its entirety. Specifically, the author considered what elements seemed to be useful, which were not useful, and what other elements may be useful in their application to educational game design. Several strategies were employed to facilitate the author's reflection.

Analysis of Design Decisions

First, the journal of design decisions that was kept throughout the study (excerpt provided in Appendix J) was analyzed. Each of the 220 design decisions recorded in the journal was based on the justifications listed in Table 17. Generally, an attempt was made to ensure that all design decision followed, or at least did not contradict, the recommendations made by the TSCL. This primary criteria for making design decisions is consistent with the formative research methodology which prescribe that the theory which is being created/improved be applied as purely as possible.

Another criterion which was always considered in making design decisions was in the alignment the design decision had with the learning objectives of the game—the effective application of the diffusion of innovations concepts.

The factors which influenced design decisions (listed in the first column of Table 17) were not ordered by priority to be used for making design decisions. Outside of giving priority to remaining consistent to the TSCL and the Diffusion of Innovations theory, the designer considered all of these factors when making design decisions. Justifications for making design decisions were not mutually exclusive. Frequently, several factors influenced a single design decision.

Table 17:

Frequency of Justification use in making Design Decisions

Justification used in making Design Decision	Round 1	Round 2	Round 3	Round 4	Round 5	Round 6	Total	Percentage
Design Expertise (Researcher and others)	17	29	16	9	25	13	109	49.5%
4C/ID Model; Ten Steps to Complex Learning	22	20	4	4	12	5	67	30.5%
Findings from evaluation: usability testing	0	0	22	11	10	4	47	21.4%
Knowledge of content (Diffusion of Innovations)	12	1	1	1	13	5	33	15%
Consistency with the original design	13	4	2	0	10	3	32	14.5%
Improve Usability	0	14	7	2	4	0	27	12.3%
Consistent with previous levels	0	0	0	0	7	4	11	5%
Technical Ability and/or affordance of software	0	2	3	1	0	0	6	2.7%
Resources (Including Money and Time)	2	1	1	0	0	0	4	1.8%

The table also shows the number of times that each justification was used in making design decisions for each round of formative data that was completed. Each round consisted of the design and development of a portion of the game followed by the data collection and analysis which in turn informed future iterations of design and development. Therefore, the analysis of the data collected in round 1 informed the design decisions made during the design and development phase of round 2.

Many of the design decisions had multiple justifications. For example the creation of the Level 1 instructional video was credited to both the 4C/ID Model (providing supportive information prior to task completion) and design expertise (using a video to provide the information and designing the video to provide information in an effective manner). The later design decision to shorten the length of the first instructional video was primarily credited to findings from usability testing.

Reflecting on the Journal of Design Decisions was helpful in understanding what the designer relied on most frequently to make decisions. As Table 17 reveals, the justification for 109 of the 220 design decisions was attributed, at least in part, to the design expertise of the researcher and of others who provided suggestions to the researcher. The expertise of the designer therefore had a very large effect on the design of the overall game. Another designer, following the same Instructional Design model, may have produced a very different version of the game.

The next most common justification used to support design decisions was the prescription offered by the TSCL. The TSCL (and underlying 4C/ID Model) were most frequently used in the preliminary stages of development. As Table 17 reveals, 42 of the 67 design decisions informed by the ID Model were made in the first two rounds of formative research. Therefore, for this designer and this particular design case, the 4C/ID

Model was most important in the early planning stages of the game. This is logical because the 4C/ID Model provides a general framework for how to organize tasks, scaffold instruction, and provide various types of information. Therefore, designers following the 4C/ID Model will have to rely on other sources (such as their design expertise) to make the more detail-oriented design decisions (or development decisions) that are required throughout the creative process of designing and developing an educational game.

The findings from the iterative cycles of formative research were the next most commonly documented source for making design decisions with all 47 instances coming in the last four rounds. Participants' comments during gameplay, their responses during the interview, and the researcher's observations of gameplay were very helpful in improving the quality of existing instructional elements and identifying instances where additional instructional elements were needed.

Condition/Method Pairs

Another approach the author took in reflecting on how to improve the 4C/ID Model and the TSCL in their application to games was to consider condition/method pairs that may be appropriate for the design of instructional resources, or some subset of instructional resources (such as digital games). A condition/method pair means that given a particular condition, a specific method is prescribed. For example, a condition/method pair already present in the TSCL is the use of part-task practice (the method) to develop skills which require a high level of automaticity (the condition).

- **IF** a high degree of automaticity is needed, **THEN** use part-task practice.

Another example of a condition/method pair already existing in the TSCL is:

- **IF** needed information is procedural, **THEN** provide it in a just-in-time fashion.

Upon reflection, several condition/method pairs were identified that might improve the TSCL in its application to the DSG, and possibly to other educational games with complex learning objectives.

The first set of condition/method pairs involves the persistence of textual information. The issue of information persistence was discussed in more detail in the “Round 5 Reflections” section. Building on that previous discussion, the condition/method pairs that might be of use regarding information persistence are:

- **IF** the learner needs to refer to information frequently, **THEN** the information should be persistent (visible to the learner at all times).
- **IF** the learner needs to refer to information rarely, **THEN** the information should not be persistent (accessible through pop-up windows or other non-persistent elements).
- **IF** the learner needs to refer to information infrequently but without distraction from gameplay, **THEN** the information should be easily accessible via elements such as roll-over text.
- **IF** some learners rely on the information to varying degrees, **THEN** the method of information access should be adjustable by the learner.

Another set of condition/method pairs relate to games which have stochastic outcomes to player input. Potential condition/method pairs that may improve the TSCL in its application to educational games which have *stochastic outcomes* are:

- **IF** the stochastic game outcome is expected (a positive result to a game action that is appropriate, or a negative result to a game action that is inappropriate), **THEN**

the player should be provided some cue that the outcome was consistent with the appropriateness of the game action taken.

- **IF** the stochastic game outcome is unfortunate (a negative result to a game action that is appropriate), **THEN** the player should be provided some cue that the action was appropriate despite the negative outcome.
- **IF** the stochastic game outcome is fortunate (a positive result to a game action that is inappropriate), **THEN** the player should be provided some cue that the action was inappropriate despite the positive outcome.

For each of these condition/method pairs, the cues should be faded so that once the player internalizes the stochastic nature of the game; they are able to progress with tasks without being informed whether or not their choice was appropriate. This is consistent with the 4C/ID Model in that players should be able to complete the last task of each task class with no instructional support.

It is likely that many additional condition/method pairs would be helpful in prescribing the best way to provide instruction within a game that simulates the real-world. This study revealed that players were distracted from learning and frustrated with outcomes due to inconsistencies in the game and the real-world in which it was simulating. However, this study provided little insight into the best ways to address these issues.

Trade-offs

Still another strategy used to stimulate reflection on the applicableness of the 4C/ID Model and the TSCL to the design of educational games was to consider acceptable trade-offs. For example, could the variation within a task class be omitted in order to save the development time and other resources needed to offer this variation? Which elements

of the 4C/ID Model are necessary and which could be disregarded? In considering which prescriptions were more or less useful, the author reflected on the compromises that were made in re-designing the DSG.

The organization of whole tasks within task classes which rely on the same mental model is fundamental to the 4C/ID Model and therefore was attended to throughout the re-design of the DSG. Likewise, the variation between tasks and fading instructional support within each task class was used throughout the design. Based on participant feedback, the use of varied, holistic, and authentic tasks organized in a simple-to-complex manner with fading instructional support was appealing and helpful for learning. Because of this participant feedback and because the tasks and task classes are the most fundamental aspect of the 4C/ID Model, ignoring this prescription would likely have compromised the quality of the game significantly. However, trade-offs were made which relate to the number of tasks and task classes used.

Though the initial design of the DSG (Appendix A) consisted of five levels (task classes), the final version of the game consisted of only three. This reduction in the number of levels corresponds to the reduction of learning objectives. Specifically, instructional content related to the concepts of gatekeepers and of formal leaders was not provided in the re-designed version of the DSG as originally intended. This trade-off was well supported by the TSCL because of the requirement that the first level embody the most fundamental aspect of what is to be learned and that each subsequent level provide instruction for the next most fundamental aspects that should be learned. Following this logic, the last levels would cover the less fundamental aspects of what is to be learned. Therefore, if a lack of resources (e.g. time and money) restricts the last levels of the game

from being developed, the most important concepts which should be learned remain and only the less important concepts will be omitted.

Another trade-off that was made in this study was in the reduction of objectives in the last level. The TSCL prescribes several tasks within each task class which range from a worked-out example (much instructional support) to a traditional, authentic task (no instructional support). However, the time needed to develop the number of objectives in the last level to support this method of scaffolding was not available. Instead, only two objectives were used. The first was not a worked-out example, but did provide instructional support to guide the player to make effective choices. The second was the original version of the DSG which provided no instructional support. Reducing the number of tasks in a task class may cause the transition from one task to the next to be too difficult. Additionally, less tasks in a task class provides learners with less opportunity to transfer what they are learning to new situations. In the case of the DSG, this appeared to be an acceptable trade-off because the post-test scores related to the concept that was to be learned in the last lesson were high.

The reduction of objectives in subsequent levels made sense with the DSG because the time to complete tasks increased from level to level. The first level which consisted of four objectives took much less time for participants to complete than the second level which consisted of three objectives or the third level which consisted of only two objectives. Other games designed following the TSCL (which prescribes that objectives rely on an increasingly complex mental model) would likely involve tasks that require an increasing amount of time to complete. Additionally, it is logical that the learner be provided with more repetition in earlier levels because they involve the learning of the most fundamental concepts. Therefore, it is logical that the prescription to provide more

tasks in the earlier task classes than in the later task classes would be worthwhile in the design of most educational games.

Fading Instructional Support within Task Classes

As part of the summative reflections, the author also considered the prescription of the TSCL to fade instructional support within task classes. The TSCL prescribes that the tasks (objectives) within task classes (levels) provide scaffolding for learners. In the first task of a task class, they should be provided with a great deal of instructional support. Each subsequent task in the task class should then require the learner to complete the task with less help until the learner is able to complete the last task of the task class with no instructional support. Faithfulness to this prescription is demonstrated by the decreasing number of mini-messages used in each of the objectives (see Table 18). All messages related to how to play the game (game mechanics) or how to apply diffusion of innovations concepts to facilitate the adoption of an innovation (the instructional content).

Table 18:

Number and Type of Mentor Messages for each Objective

Level, Objective	Number of messages providing information about game mechanics	Number of messages providing information about instructional content	Total number of mentor messages
1, 1	17	4	21
1, 2	13	3	16
1, 3	6	0	6
1, 4	3	0	3
2, 1	10	5	15
2, 2	6	2	8
2, 3	3	0	3
3, 1	7	0	7
3, 2	0	0	0

The reduction of messages within each level is just one indication of fading instructional support. Instructional elements (such as the sorting activities, Probability Spinner, “KEY INFORMATION” button, Activity Log, Adopter Type icons, and Social Network icons) were removed in the later objectives of each level as well.

Fading instructional support does not necessarily equate to fading game elements (such as advanced organizers) that players have become dependent on. Consider the sorting activities for example. Fading instructional support does not require that the activity be taken away from the player. The player could still have the ability to sort activities into what they believe is the appropriate phases of adoption, and sort people into the Adopter Types they feel the people belong, without receiving any instructional support

(corrective feedback) to tell them whether or not they sorted correctly. Participant 17 expressed this notion by saying “I would also like a way to create my own graphic organizer to keep track of connections/notes in the final section [the original DSG] or else a better graphic organizer provided. The one in the training module [the social network icons in Level 3, Objective 1] was very nice – easy to understand and see connections at a glance.” This information could be provided in the final objective of the level (the original DSG) because it is not providing any instructional support, but instead just providing the information already present in the social network diagrams, in a more useful way to the player.

Chapter 13: Summary and Discussion

This last chapter provides a brief summary of the entire study in order to bring perspective to the discussion of the meaning of the results in the context of other instructional design theories and research. Trustworthiness of the findings is discussed next. Limitations of the study are then described. Finally, suggestions for future research are provided.

The Problem

Educational game designers may benefit from instructional design (ID) theories that offer a prescription of how to design educational games. However, a review of the literature revealed few ID theories specifically for the design of educational games and those which were found have not been rigorously evaluated.

The *Ten Steps to Complex Learning* (TSCL) may be particularly useful to educational game designers in designing educational games which have complex learning objectives. However, a literature review provided no cases in which the application of the TSCL to educational games had been studied nor did it reveal any alternative educational game design models which are intended to support complex learning.

Given the increasing trend to use digital games for training and educational purposes, there is an increased need to create educational games which are appealing and effective in promoting learning. An empirically valid framework for creating appealing and effective educational games would likely improve the quality of educational games that are being produced.

The Purpose

The primary focus of this study was to investigate the applicability of the TSCL for educational game design and how it might be improved for this purpose. Additionally, the detailed design case which was a byproduct of the study was intended to be used by educational game designers as precedent of following an ID theory to create educational games.

The Methods

In this study, formative research methodology was used to *improve* the TSCL by applying it to *re-design* the Diffusion Simulation Game (DSG). This case study approach to improving theory required an iterative approach of designing (following the TSCL), developing, and collecting and analyzing formative data which informed subsequent iterations. Six iterations of this process were completed in this study resulting in a re-designed version of the DSG.

The DSG was selected as the design case for this study for several reasons. First, the author had access to the code and permission to modify it. Second, prior research on the DSG had revealed that players who were given minimal or no instruction prior to, during, or after gameplay, were not adequately meeting the learning objectives. Players in these studies were often overwhelmed with the complexity of the game. Therefore, the DSG was a good candidate for testing the TSCL, which is intended to guide instructional design of complex learning.

In each of the six rounds of formative research, new objectives (learning tasks) were developed and/or objectives created in previous rounds were modified. Two to four participants were then recruited to complete a demographic survey, take a pre-test of

learning, play through all of the objectives that had been developed while talking aloud about their game strategies (both the audio and screen was recorded), take a post-test of learning (which was the same as the pre-test), and then respond to the questions of a semi-structured interview.

In total, 20 people participated in the study. These participants were all recruited from post-secondary institutions and were in academic programs which offered a course in change management or diffusion of innovations. In Round 1, four participants played through three objectives of the first level. In the sixth and final round, the final four participants played through four objectives that made up Level 1, three objectives that made up Level 2, and two objectives that made up Level 3.

In addition to collecting data from participants (demographic survey results, pre- and post-test scores, gameplay data, and interview responses), the author also collected observation data throughout the study in the reflections made after each round of formative research (Appendix K) and in a journal of design decisions (excerpt in Appendix J).

The analysis of the data provided evidence that the re-designed DSG was mostly effective in meeting its learning objectives and that most participants found the game to be appealing and engaging. More importantly, the data analysis provided a means to answer the research questions of the study and ultimately provide tentative improvements to the TSCL that would have made it more useful in the re-design of the DSG.

Research Questions and their Answers

Two research questions guided the study. They were:

1. How could the TSCL have been more useful in re-designing the DSG to be effective and efficient to the players who participated in this study?

2. How could the TSCL have been more useful in re-designing the DSG to be appealing to the players who participated in this study?

The TSCL provided fundamental guidance in initial stages of redesigning the DSG. Of the 220 design decisions recorded in the journal, 67 were at least partially made based on recommendations by the TSCL. As Table 17 reveals, 42 of the 67 design decisions informed by the ID Model were made in the first two rounds of formative research. Therefore, in this study, the TSCL was most important in the early planning stages of the game and less important in the later stages focused more on development, improvement of content, and tweaking of the game difficulty.

Eight additional scenarios were developed and grouped into three task classes arranged in increasing complexity. This approach was helpful in providing instruction to learners in a simple to complex manner. Many of the players voiced beliefs that the use of several scenarios which became more and more complex was beneficial to learning, increased their confidence, and made the game more appealing. However, the TSCL by itself was insufficient in re-designing the DSG so that players would meet the learning objectives.

While the TSCL provided guidance on **when** to provide information (depending on whether it was supportive or procedural in nature) to players, it did not provide guidance on **how** to provide that information in a digital game environment. In this study, the designer used several strategies to present information to the player in a manner in which the player would pay attention to it.

One strategy was to vary how the information was presented to players and how easily accessible the information remained to players. Some information was displayed on the screen at all times for players. Other information could be accessed quickly without

breaking player emergence into the game via links and icons which could be moused over to display information. Pop-up windows required players to leave the game space temporarily to access some information. At times, players had the option to have the information displayed based on their preference. In re-designing the DSG, deciding how the information was presented to players and how easily accessible the information remained to players generally depended on the importance of the information, the frequency in which players need to access the information, or how previous attempts of providing the information to players succeeded or failed.

Several other strategies were used to get players to attend to information provided in the re-designed DSG. One strategy used was to provide the information repeatedly to the player and/or use multiple methods to introduce the learner to content. Another strategy used was involved emphasizing key information in order to increase the probability that players will attend to the information. At times, it was useful to rely less on text for conveying information and more on visual elements, animation, and interactive elements.

Every piece of information in the game had to be provided to the player in one or more ways. How to best provide information so that players attend to it was a challenge throughout the study in which the TSCL provided no guidance for.

The TSCL was also insufficient for re-designing the DSG in its lack of guidance related to concepts which learners have a difficult time accepting. In the DSG, several strategies were used to overcome players' strongly held beliefs when they did not align with the game. For example, to address players' difficulty in understanding the stochastic nature of the game, game elements (such as the Probability Spinner and the Activity Log) were added to correct misconceptions that commonly occur during gameplay due to premature conclusions made by players based on unfortunate outcomes. It may have been

helpful for the TSCL to have provided guidance on how to deal with instances when the game does not simulate the real world as closely as players expect, or when players beliefs are inconsistent with the simulation and/or the real-world.

The TSCL was also insufficient in that it did not **require** an iterative process of design and development. The iterative design and development process used in this study was essential in re-designing the DSG to be effective for learning. Requiring, instead of suggesting, that the TSCL be used within an ISD process would have been appropriate for the re-design of the DSG because, as a digital game, bugs and usability issues sometimes completely suspended all desired learning from occurring.

Providing an initial learning task prior to any supportive information was identified as an adaptation to the TSCL which may have improved its usefulness in re-designing the DSG. This is inconsistent with the TSCL which prescribes that supportive information be presented prior to the tasks which rely on that information. However, modifying this prescription may be appropriate when designing educational games for several reasons. First, providing supportive information *after* players have had time to learn to play the game, instead of simultaneously, may reduce the cognitive load of learners while they are familiarizing themselves with the gameplay. In this manner, players will have already learned how to play the game before concerning themselves with how to play it *well* (applying what they learn through supportive information). Secondly, providing players with the opportunity to complete the task prior to giving instruction would allow them to immediately begin gameplay (possibly increasing appeal) and also provide them with an experience to reflect back on when the supportive information is introduced. If this adaptation of the TSCL were implemented, players would be expected to find the supportive information more meaningful, because they would have a very recent experience on which to reflect.

In summary, while supplemental strategies were needed to enhance learning and address deterrents to learning that were revealed during the study, the TSCL provided the structure which informed the initial design of the game. The unique, detailed design case in this study has contributed an important precedent for developing educational games and has provided evidence that the TSCL can be effectively used to design educational games.

Implications

In addition to the tentative recommendations for improving the *Ten Steps to Complex Learning* (TSCL), implications drawn from the current study may add to prior knowledge of instructional design of educational games and may influence the perspective of educational game designers and scholars.

Trial-and-Error Learning

First, several scholars take the position that games are good for learning because they allow the player to learn via trial-and-error with minimal real world consequences. One example of this mindset discussed previously in Chapter 2 is given by Masie (2006) who believes that intermediate failure is not considered a bad thing in the world of gaming, but instead a step on the way to winning. “You can fail forward. In other words, you can fail until you succeed” (Masie, 2006, p. 35). James Gee, a prolific writer on the topic of learning through games, states:

Good video games lower the consequences of failure; players can start from the last saved game when they fail. Players are thereby encouraged to take risks, explore, and try new things. In fact, in a game, failure is a good thing. Facing a boss, the player uses initial failures as ways to find the boss’s pattern and to gain feedback about the progress being made. (Gee, 2005, p. 35)

However, this common belief may need to be investigated more carefully. In comparing the player experience of participants in this study (those who played the DSG

with embedded instruction following the TSCL) with participants in prior studies (those who played the original DSG with little or no instructional support), embedded instructional support (provided by following the TSCL) appeared to alleviate frustration of players and to lessen misconceptions developed through gameplay. While games allow players to fail with few or no real-world consequences and learn from their mistakes in an engaging way, well designed instructional support may be appropriate for players with particular characteristics (such as those who have a low threshold for failure or do not have time to learn in a trial-and-error fashion) or for particular content (such as content which is complex in nature and may be difficult to learn through only trial-and-error).

Frick (2012) provides another perspective for the value of learning through designed instruction over learning by accident or by trial and error. He states that intentional guided learning “has been the major means by which human civilization and culture have advanced” (Frick, 2012, p. 6). Frick explains that the essence of education is “intended guided learning.” Given this conception of education, he believes “there is an inherent contradiction between games that promote learning by trial and error and those games that are educational” (personal communication, July, 2012).

Every game has challenge and therefore will have the possibility of failure. If players never experience failure, they will likely find the game too easy and therefore boring. Game designers must work to provide the appropriate level of challenge and, for educational games, the appropriate level of instructional support. Prescriptive ID theories (such as the TSCL) can provide useful guidance to designers for when and how to provide that support.

Minimalist Instruction

While well designed instructional support may promote learning in educational games, designers should be selective in the type and amount of instructional support they provide. A typical gamer's expectation of educational games would be that learners should be provided the opportunity to "play" the game without being overly bombarded by instruction which interrupts the gameplay.

To reduce gameplay interruption and further reduce the cognitive load of learners, the TSCL may be improved in its application to educational game design by adopting a minimalist approach to instruction. The central problem that led John Carroll and other scholars to develop minimalist approaches to instruction in the late 1980's was their astonishment at "the profound difficulties people routinely experienced in using what appeared to be carefully designed documentation and self-instruction material" (Carroll, 1998, p. 1). Culatta (2012) indicates that "[t]he critical idea of minimalist theory is to minimize the extent to which instructional materials obstruct learning and focus the design on activities that support learner-directed activity and accomplishment" (n.p.).

Carroll (1998) discusses four fundamental principles for designing minimalist instruction. Three of these principles are discussed below in relation to the TSCL.

Principle 1: Choose an action-oriented approach. This principle is consistent with the central use of learning tasks in the TSCL. However, Carroll recommends that the designer should provide an "immediate" opportunity to act:

A priority in designing minimalist instruction is to invite users to act and to support their action. Of course, instruction for skill domains always seeks to support user activity, but often it does not make immediate activity a high enough priority. For example, tutorials often begin with an explanation of how the application and instruction work or an orientation to the semantics of the domain. Such

explanations are valuable to the learner, of course, but, positioned at the very entrance to the manual, they constitute a distraction. The learner is confronted with prerequisites to action instead of the opportunity to act. An alternative approach is to begin by giving the user less to read but more to do. (Carroll, 1998, p. 22)

This principle appears to be contradictory to the TSCL, which recommends that the learner should be provided with instructional support *prior* to beginning the learning tasks. The minimalist approach to instruction therefore supports the tentative recommendation made in the conclusions of this paper that supportive information should be provided only after the learner has had an initial opportunity to play some form of the game.

Carroll (1998) suggests additional heuristics to support the effective application of his first principle which may be useful in enhancing the TSCL in its application to games. For instance, encouraging and supporting exploration and innovation is a guideline of the minimalist approach which is well aligned with affordances of many games. Additionally, the minimalist approach encourages designers to respect the learners (whose expertise and learning styles often vary) by giving them control of their own activities. One method to ensure that learners would feel in control of their own activities would be to provide guidance in an optional manner, accessible just in time, when they need it.

Principle 2: Anchor the tool in the task domain. This principle highlights the need to avoid making the tool or application (in this case, the educational game) the user's principle objective. Learning to play a game is merely a means; "it is almost never an end in itself" (Carroll, 1998, p. 28).

Consistent with the TSCL, the minimalist approach to instruction promotes the selection or design of real-world tasks that are anchored in the task domain. This minimalist principle is consistent with the TSCL's recommendation to use authentic learning tasks that learners recognize to be useful in their own lives.

Principle 3: Support error recognition and recovery. This principle highlights the need to reduce errors and streamline a learner's detection, diagnosis, and recovery of those errors. While Carroll suggests some strategies to support this principle, he also suggests that the designer attempt to reduce the occurrence of the mistakes. "The best way to remedy some mistakes is to help users avoid making them in the first place" (Carroll, 1998, p. 35).

Moreover, iterative usability testing is an indispensable method for detecting errors that are difficult to predict (Carroll, 1998). The detailed design case in the present study corroborates this claim, in which 21.4% of the design decisions were at least partially attributed to usability findings (see Table 17).

This minimalist principle is consistent with the tentative recommendation made in the present study: educational game designers should apply the TSCL within an ISD process. Use of the TSCL within an ID process should be a requirement, not an option, when designing and developing educational games.

Iterative Approach to Design and Development

An ID *model* provides a description of how instruction should be provided to learners. For example, the 4C/ID Model provides a blueprint of what instruction should look like to support complex learning. An ID *theory* prescribes how to design instruction. For example, the TSCL is an ID theory which provides procedural guidance on how to design instruction to support complex learning. *Instructional design* (ID), as a process, involves following steps or guidelines (via ID theories or design expertise). Van Merriënboer and Kirschner (2007) promote an iterative zigzag approach to designing instruction and recommend that the approach be conducted within an Instructional

Systems Design (ISD) process. ISD, as a process, goes beyond design and generally include assessment, design, development, implementation, and evaluation (van Merriënboer, 1997).

In this study, the author found the iterative zigzag approach embedded within an ISD process to be of great importance to designing an appealing game that was effective in promoting the learning objectives. The iterative zigzag approach involved following the steps provided by the TSCL in a non-sequential and repetitive way. The ISD process allowed for continuous improvements informed by frequent testing with users, followed by evaluation of observations of user tests. The challenges resulting from the variability in how players proceed through a game, their individual characteristics, and emergent gameplay that arises from unintended gameplay, can all be addressed from employing an ISD process to game design.

An observation from this study related to the use of an ISD process was that the design, development, and evaluation *differed* in each iteration of the study. In the first iteration, the design focused largely on the basic structure of the game and the mechanics of gameplay—the “bones” of the game. In subsequent iterations, the design decisions were generally more specific—the “meat” of the game. In this study, the development cycle involved improving previously created objectives, creating new objectives, or a combination of both. This depended mostly on the results of the most recent evaluation that had been conducted. If significant improvements were needed, then the focus of development would be on improving the current objectives instead of developing additional objectives. Alternatively, if there were few modifications needed, the development of new objectives ensued. This approach may be a result of having a single

individual working on the game instead of a team of designers, developers, and researchers.

Still, the variation in each iteration of design, development, and evaluation should be considered. In this study, it was useful to take notes during each gameplay session to be incorporated in the semi-structured interview that was used as part of the evaluation after the game session. Using a flexible set of interview questions facilitated the differences that arose in each iteration. This flexibility also helped to accommodate individual differences in each player's game session.

The TSCL recommendation to use the steps as needed in an iterative manner greatly strengthened the new version of the DSG created during this study. Other ID theories focus on holistic learning tasks, discussed in the literature review (Chapter 2). These theories also recommend a flexible and iterative approach to instructional design (e.g. Merrill's *First Principles of Instruction*, Reigeluth's *Elaboration Theory*). Similarly, Molenda (2003) notes that ISD processes are often described by the acronym ADDIE (Analysis, Design, Development, Implementation, and Evaluation). ADDIE is normally applied in an iterative, yet sequential, manner. Finally, the iterative nature of current ID Theories and ISD processes is consistent with methods of rapid prototyping frequently applied in game production.

Unique Precedent

Precedent is described by Oxman as “the unique knowledge embedded in a known design” (qtd. in Boling, 2010, p. 2). Precedent which results from scenario-based design may be especially useful to educational game designers who wish to learn from other specific game design cases. In other words, unique precedent allows other designers

opportunity to learn about the design case without having to witness the case directly. By reading through the *story* of a design, designers may develop familiarity with, and possibly appreciation of, other designers and their work. Chapters 5 through 10 tell this story.

Carroll (2000) discusses *scenarios* of human-computer interaction as one form of unique precedent. Carroll describes scenarios as stories about people and their activities with the characteristic elements such as a setting, agents or actors, goals or objectives, and a plot. “They include sequences of actions and events, things that actors do, things that happen to them, changes in circumstances of the setting and so forth” (Carroll, 2000, p. 45). By this definition, any detailed design case, including the description of the re-design of the DSG provided in the study, instantiates a scenario. The unique details of a particular design case (e.g. setting, actors, goals, plot, etc.) constitute *unique precedent*.

While the unique precedent of the design case resulting from this study (the re-design of the DSG) made it difficult to generalize the findings related to improving the TSCL, it did not detract from the usefulness of the design case itself. Boling (2010) points out that the purpose of precedent from design cases is not to generalize disembodied ‘lessons learned’ for future designing. Instead, designers should be able to determine which elements of the design case are transferable to their own design space. “Designers develop the ability to size up situations rapidly and determine the fit, if any, between the potentials embodied in precedent and the current situation” (Boling, 2010, p.4).

Boling (2010) defines a design case as “a description of a real artifact or experience that has been intentionally designed”. She explains that a design case can be as simple as an image of a final designed product to a comprehensive description of the entire design process from the inception of the idea to the implementation, and possibly ultimate destruction, of the artifact.

The necessity for rigorous design cases is argued by Boling (2010) who notes that the need is even greater in the field of instructional design where little precedent is currently available. “A body of design cases that offer in-depth explanations of design rationales, rich and multi-dimensional descriptions of designed artifacts and experiences, and full reflection on design processes have the potential to offer teaching and learning opportunities that are difficult to find and that may especially benefit students of design across multiple fields” (Boling, 2010, p.6).

This study provides unique precedent, in the form of a rigorous design case described in considerable detail, which can be used by designers to learn design. Other scholars who design an instance to test a theory (as described by the formative research methodology) should consider providing a rigorous account of their design case. This not only provides a rich description of how the study was conducted, but gives designers a design case to enrich their own design knowledge.

Activation

As discussed previously in the *Minimalist Instruction* section of this chapter, Carroll (2000) recommends an action-oriented approach that provides an immediate opportunity to perform a task. This minimalist principle, along with reflections made during this study, provides some justification for designing educational games so that at least some gameplay occurs prior to any instruction. A tentative recommendation for the TSCL in its application to designing educational games is to initially provide learners with experience in playing a game *prior* to providing supportive information up front as the TSCL currently recommends.

Futhermore, *activation* is one of the principles of the *First Principles of Instruction* discussed in Chapter 2, which adds credibility to this recommended change to the TSCL guidelines. *First Principles of Instruction* are consistent with TSCL in that they focus on real-world problems (authentic learning tasks) and include an initial demonstration (worked-out example) of how to complete a learning task. However, Merrill's activation principle is not a central component of the TSCL. The purpose of activation is to ensure the learner has the prerequisite knowledge and experience needed to learn the new material. If learners already have the prerequisite knowledge and experience, then this existing experience can be activated by providing them with an appropriate opportunity to demonstrate what they already know. "This activity can be used to help direct students to the yet-to-be-learned new material and thus result in more efficient instruction" (Merrill, 2000, p. 47). If the learner has no prior knowledge, then activation may be achieved by providing learners with an experience upon which later learning can be built.

Whether activation is provided through recalling prior experiences or providing new experiences, educational game designers can implement the concept by providing learners with immediate in-game tasks which activate prerequisite knowledge. By activating the prerequisite knowledge before introducing the new material to be learned, the cognitive load of learners may be reduced. Gameplay itself may be considered prerequisite knowledge that learners need to know in order to play the game. With this viewpoint, activation would involve providing learners an opportunity to complete a task which would help them acquire the prerequisite knowledge of how to play the game. Once this and any other needed prerequisite knowledge is activated, the supportive information for the new content to be learned could be introduced to the learner. Finally, activation is

important for helping learners see the relevance of what they are to learn, by connecting what they already know to something new to learn.

Trustworthiness

The issue of trustworthiness where a single case is being studied and the author is intimately involved as a designer and developer in the study was addressed in several ways throughout the study. First, an attempt to remove bias was made. For instance, the pre- and post-tests were graded independently and blindly by two graders. The joint probability of agreement was 0.84 on the pre-test and 0.86 on the post-test. Afterwards, disagreements in scores were discussed by the graders until 100% agreement was reached. Completing quantitative analysis on the qualitative data collected (e.g. frequency of design decisions) and getting input from colleagues were also methods which were helpful in alleviating potential bias.

Another strategy which improved the trustworthiness of the results is that several sources were used to confirm that the TSCL were being followed appropriately. Prior to the study, the proposal of the study was approved by a dissertation committee which comprised experienced instructional designers, experts on research methods, and the creator of the TSCL. During the study, the dissertation committee chairman provided guidance for conducting the study and progress was shared intermittently with the chairman's SimEd research group. The research group also provided feedback on how to develop the DSG following the TSCL and how to conduct the study to effectively answer the research questions.

In addition, the detail provided in the design case helps to support trustworthiness of the results. Boling (2010) discusses how emphasis on rigor:

... focuses on support of the reader—building trust in what has been reported, providing context that allows independent assessment of what has been reported by

the reader, and committing to transparency in conveying the particular situation rather than to process in deriving the general rule. (p. 6)

Ecological validity is a further factor that supports trustworthiness. “For a research study to possess ecological validity, the methods, materials and setting of the study must approximate the real-life situation which is under investigation” (Ecological Validity, n.d., n.p.). Ecological validity should be apparent to the reader via the design case. By providing sufficient detail in describing the actual design case, the readers have the opportunity to judge the ecological validity of the study (see Chapters 5-10).

Limitations

First, this study was not funded and was completed by one individual over a two year period to fulfill the requirements of a doctoral dissertation. The limited time frame and budget was prohibitive in the design and development of the DSG and in conducting the study. In particular, the study would have been strengthened by conducting additional rounds of Formative Research (and further iterations of design and development). The lack of resources likely hindered the effectiveness of the re-designed DSG and limited what was learned about the application of the TSCL in its application to the re-design of the DSG.

A significant limitation of the study (resulting from the use of the Formative Research method) is that the findings from the single-case study cannot be generalized. In this study, the design case only provides readers a rich description to enable them to make judgments of transferability to similar situations and indicates tentative modifications that may improve the TSCL in its application to the design of educational games, or some subset of educational games.

This limitation is amplified because the case selected for the study (the re-design of the DSG) involved modifying a game which already existed and was relatively successful. Instead of designing the gameplay from scratch, the core game mechanics which already existed were kept. Therefore, in this study, the application of the TSCL involved subtracting out game mechanics for the simpler tasks and gradually adding them back in for the more complex tasks. Applying the TSCL to an educational game being created from scratch may reveal much more about how useful the TSCL is for educational game design and about how the TSCL could be improved for this purpose.

Because the TSCL provides no guidance directly related to game design, it is likely that additional guidance would be needed when designing new educational games, compared with re-design of an existing game as done in this study. There are several sources for guidance in game design. For example the Game Flow model provides eight elements of games that can be used to increase player enjoyment (Sweetser & Wyeth, 2005). These eight elements are (1) the game (a task that can be completed), (2) concentration (ability to concentrate on the task), (3) challenge player skills (perceived skills must match challenges and both must exceed a certain threshold), (4) control (allowed to exercise a sense of control over actions), (5) clear goals (the task has clear goals), (6) feedback (the task provides immediate feedback, (7) immersion (deep but effortless involvement, reduced concern for self and sense of time), and (8) social interaction. The GameFlow model is a framework for *evaluating* game enjoyment based on the eight elements derived from games literature. However, the model was provided for participants of a recent study at three sites of the 2011 Global Game Jam to support their game design efforts, not for evaluation purposes (Ke, Yildirim & Enfield, 2012).

An alternative set of game elements that could be considered are offered by Sivasailam Thiagarajan (2003). He provides four critical characteristics of games: *conflict* (goal must be achieved by overcoming obstacles), *control* (game mechanics and rules of the game), *closure* (the game must end), and *contrivance* (built in inefficiencies of the game). Thiagarajan identifies *competency* as a fifth characteristic that is critical for games which are designed for training purposes (the competencies in which players should develop by playing the game). Many other frameworks are available to support game design, some of which are described in Chapter 2 (the review of literature).

Just as the product is unique in studies involving Design Based research, so is the designer. In this study, the designer was intimately involved in every design decision and so the designers' beliefs and design expertise greatly influence the re-design of the DSG. A different designer following the same TSCL would likely create a very different game. Even the design of smaller elements of a game may have varied greatly between designers. For example, the chair of this dissertation study believes that the instructional videos may have been more effective if they included images of unique instances of what was being described:

[The instructional videos which were used in the DSG were] largely words with some graphics. According to C. S. Peirce, words are symbolic signs, which stand in contrast to iconic and indexical signs. For example, think of TV newscasts. Whenever possible, newscasters routinely supplement their commentary (symbolic signs) with "live shots" or a recording of previous live action. Newscasters just don't give the final score of the basketball game, but often provide some video excerpts of that actual game itself (indexical signs) along with their commentary; or the story about the automobile accident shows pictures of the actual crushed car along the roadside with debris scattered nearby (also indexical). In other words, video can be used more effectively by providing viewers with concrete, unique images. Such video provides indexical signs that accompany symbolic signs. It helps to ground the symbolic signs provided in the newscaster commentary. This is the "show me" principle. Don't just talk or show me words on the screen or pictures of people talking about it—show me the real thing. (personal communication, May, 2012)

Additionally, it is important to note that the author was a novice in using the TSCL and had a unique set of prior design expertise — both factors that influenced the importance given to and the amount of energy spent on each step of the TSCL.

Another limitation of the study was that the researcher may have unintentionally influenced interview responses and gameplay. In particular, observing the gameplay session and asking participants to “think-aloud” may have caused participants be more thoughtful and reflective in their game choices than they would have been otherwise. Simply being aware that they were being observed may have caused anxiety and affected learning. Participant 19 voiced this concern, stating in the interview that “The fact that I was being observed and not completing tasks quickly or at all was not helpful to my learning.”

Future Research

More research is needed to understand how the TSCL can be applied to educational games. One strategy for doing this is to repeat this study with other cases (different designers and different instructional content or learning objectives). Repeating this study in a case in which a new game is being completely designed would also be very useful (the present study was a re-design of an existing simulation game). Once enough of these studies have been completed, suggestions for how to improve the TSCL in its application to educational games may be made.

Additionally, research could be conducted to validate and/or improve other ID theories and models in their application to game design. Whereas, the TSCL might be an appropriate ID theory for designing games which have complex learning objectives, other ID theories may lend themselves to educational games with alternative purposes.

By conducting more design-based research studies utilizing ID theories to develop educational games, the more we will learn about how beneficial those theories might be to educational game designers. These studies will not only serve to improve the ID theories they utilize, but also to provide precedent to educational game designers.

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Appendix A: Initial Vision for the Re-Design of the DSG

<p>Player choices that will be provided as the DSG begins</p> <p>Play game – No training provided (play current game as is, final level only)</p> <p>Get trained as a change agent – Apprenticeship style training via an expert mentor</p> <ul style="list-style-type: none">Information from mentor is always available for player to go back and review.(Image to dialogue popup animation)Mentor guides player through 5 levels (task classes). <p>[x] Change Agent Certification</p>
<p><u>Task Class 1: Level 1</u></p> <p>Mental Model: Appropriate tasks for adoption phase (individual)</p> <p>Context: 1 Student, New style of note-taking (Cornell Notes), 6 diffusion activities</p> <p>Whole-task: Get the student to adopt the note-taking system in his or her classes</p> <p>Supportive info:</p> <ul style="list-style-type: none">Adoption phases, Diffusion activities appropriate for each phase <p>Awareness: Provide information through Communication channels</p> <p>Interest: Provide opportunity to see the innovation being used</p> <p>Trial: Provide opportunity to try out the innovation</p> <p>Task 1: Worked-out example</p> <p>Mentor only allows player to select from appropriate tasks</p> <p>This is when basic UI and gameplay is taught to the user (through explicit cues)</p> <p>Task 2: Mentor gives corrective feedback for inappropriate activity choices.</p> <p>Summative stats are provided (appropriateness of task selection/not effectiveness)</p> <p>Task is repeated until 100% accuracy</p> <p>Task 3: Conventional task (No support from Mentor)</p> <p>Summative stats are provided</p> <p>Task is repeated until 100% accuracy</p>
<p><u>Task Class 2: Level 2</u></p> <p>Mental Model: Appropriate tasks for adoption phase (group)</p> <p>* Application of Task Class 1 to multiple people at various stages of adoption</p> <p>Context: 6 people on the board of a charter school, admission process, 6 diffusion activities</p> <p>Whole-task: Get all the board members to adopt the new admission process</p> <p>Supportive info:</p> <ul style="list-style-type: none">Mass Media Communication Channels to raise awareness and interest of many at once <p>Task 1: Worked-out example</p> <p>Mentor only allows player to select from appropriate tasks</p> <p>This is when basic UI and gameplay is taught to the user (through explicit cues)</p> <p>Task 2: Mentor gives corrective feedback for inappropriate activity choices.</p> <p>Summative stats are provided (appropriateness of task selection/not effectiveness)</p> <p>Task is repeated until 100% accuracy</p> <p>Task 3: Conventional task (No support from Mentor)</p> <p>Summative stats are provided (appropriateness of task selection/not effectiveness)</p> <p>Task is repeated until 100% accuracy</p>

Task Class 3: Level 3

Mental Model: Adopter types, identify and use Early Adopters to influence others

* Implement *Get Personal Information* activity/feature

Context: 9 Employees, Office reward system, 7 diffusion activities, Get Personal Info Activity

1 innovator, 2 early adopters, 2 early majority, 2 late majority, 1 laggard

Whole-task: Get all 9 employees to adopt the innovation

Supportive info:

Adopter types and their characteristics

Adopter type distribution

Target Early Adopters to influence others

Task 1: Worked-out example

Mentor only allows player to select early adopters/opinion leaders OR those in the trial stage

Task 2: Mentor gives corrective feedback for inappropriate employee choices.

? Also give corrective feedback for selecting wrong activity for adoption stage?

Summative stats are provided (appropriateness of task selection and staff selection)

Task is repeated until 80% accuracy?

Task 3: Conventional task (No support from Mentor)

Summative stats are provided (appropriateness of task selection and staff selection)

Task is repeated until 100% accuracy

Task Class 4: Level 4

Mental Model: Use of interpersonal communication channels (social networks, opinion leaders)

Context: 11 Rodeo clowns, safety vest, 8 diffusion activities

Networks: Rodeo Organizing Committee (formal), Lunch mates (informal)

1 innovators

2 early adopters – both are highly connected; 1 is also an opinion leader

4 early majority – 1 is highly connected and 1 other is an opinion leader

3 late majority

1 laggards

(gatekeeper #1) secretary – works for mayor

(gatekeeper #2) manufacturer – manufactures cards and card readers

Whole-task: Get all 11 Rodeo Clowns to adopt the innovation

Supportive info:

How to measure the connectedness of a staff member in a social network

How to target individuals indirectly through social network

Effectiveness of formal vs. informal network systems

Formal vs. Informal Social Networks

Task 1: Worked-out example

Mentor only allows player to select highly connected Early Adopters/Opinion Leaders

Task 2: Mentor gives corrective feedback for inappropriate choice of owners.

? Also give corrective feedback for selecting wrong activity for adoption stage ?

Task is repeated until 100% accuracy

Task 3: Conventional task (No support from Mentor)

Task is repeated until 100% accuracy

Task Class 5: Level 5

Mental Model: Use of formal leaders and gatekeepers

Context: 14 Restaurant Owners, Community rewards card, 10 diffusion activities

Networks: Restaurant Association Members (formal), Sunday Golf Group (informal)

2 innovators – 1 is the Restaurant association president (a formal leader)

3 early adopters – 2 are highly connected and 1 of them is also an opinion leader

4 early majority – 1 is highly connected and 1 other is an opinion leader

3 late majority – 1 is the mayor (a formal leader)

2 laggards

(gatekeeper #1) secretary – works for mayor

(gatekeeper #2) manufacturer – manufactures cards and card readers

Whole-task: Get all 14 restaurant owners to adopt the innovation

Supportive info:

Concept of gatekeepers

Formal leaders (compulsion/confrontation => policy mandate)

Task 1: Worked-out example

Mentor only allows player to select highly connected Early Adopters/Opinion Leaders

Task 2: Mentor gives corrective feedback for inappropriate choice of owners.

? Also give corrective feedback for selecting wrong activity for adoption stage ?

Task is repeated until 100% accuracy

Task 3: Conventional task (No support from Mentor)

Task is repeated until 100% accuracy

Mentor summarizes what was learned (using graphic) and says “GOOD LUCK”.

Final (Assessment): Level 6

Context: Current version of the game

Whole-task: Get all 22 staff members of a school system to adopt peer tutoring

Supportive info: None

Appendix B: Recruitment E-mail sent to students

Subject: Request for participation in game research study

Dear student,

I am conducting a study which involves the development of an educational game and am asking for your participation. The game is intended to help players learn about change management and the diffusion of innovations; subjects identified as relevant to your academic program.

Volunteers will be compensated \$6/hour for their participation in the study for up to \$24 total. Participation in the study will require one to four hours of time. You may participate online from anywhere or in person at the School of Education at Indiana University, Bloomington IN.

Your participation will help to improve the game's appeal, usability, and its effectiveness and efficiency in meeting its learning objectives. If you are interested in participating, please contact Jake Enfield at jwenfiel@indiana.edu for further information.

Thank you for your consideration in participating in this study.

Sincerely,

Jake Enfield

Instructional Systems Technology

Indiana University

Appendix C: Survey of Demographic Information

Demographic Survey

What is your first language?

Are you fluent in English?

How many years have you attended primary or secondary schools (k-12) in the United States?

How much time per month do you spend playing computer and video games?

List the five computer and video games which you have played the most over your lifetime?

Do you have any knowledge of the Diffusion of Innovations Theory?

Please describe all experiences you have had in trying to get a group of people to adopt something new (such as technology advancements, work processes, health practices, etc.).

Getting a new idea adopted, even when it has obvious advantages, is difficult. Many innovations require a lengthy period of many years from the time when they become available to the time when they are widely adopted. Therefore, a common problem for many individuals and organizations is how to speed up the rate of diffusion of an innovation.

Water Boiling in a Peruvian Village:

The public health service in Peru attempts to introduce innovations to villagers to improve their health and lengthen their lives. This change agency encourages people to install latrines, burn garbage daily, control house flies, report cases of infectious diseases, and boil drinking water. These innovations involve major changes in thinking and behavior for Peruvian villagers, who do not understand the relationship of sanitation to illness. Water boiling is an especially important health practice for Peruvian villagers. Unless they boil their drinking water, patients who are cured of an infectious disease in a medical clinic often return within a short time to be treated again for the same disease.

Your Mission

You are hired as a change agent for a two-year water-boiling campaign conducted in Los Molinas, a peasant village of two hundred families in the coastal region of Peru. Most residents of Los Molinas are peasants who work as field hands on local plantations. Water is carried by can, pail, gourd, or cask. The three sources of water in Los Molinas include a seasonal irrigation ditch close to the village, a spring more than a mile away from the village, and a public well whose water most villagers dislike. All three sources are subject to pollution at all times and show contamination whenever tested. Of the three sources, the irrigation ditch is the most commonly used. It is closer to most homes, and the villagers like the taste of its water.

Although it is not feasible for the village to install a sanitary water system, the incidence of typhoid and other waterborne diseases could be greatly reduced by boiling water before it is consumed. Your mission is to get as many of the villagers in Los Molinas to adopt the innovation as possible during the two-year campaign.

Describe a plan for diffusing water-boiling to the villagers of Los Molinas. Justify your plan by explaining why you think it will be effective.

adapted from Rogers (2003) *Diffusion of Innovations*, 5th Ed.

Appendix E: Initial Pre- and Post- Test Scoring Rubric

Level 1: Appropriate tasks for adoption phase (individual)		
Adoption phases (awareness, interest, and trial) are <u>not</u> integrated into the diffusion plan.	Adoption phases (awareness, interest, and trial) are integrated into the diffusion plan, but appropriate activities are <u>not</u> identified for each phase.	Adoption phases are integrated into the diffusion plan along with diffusion activities that are appropriate for each phase. Awareness: Provide information through Communication channels Interest: Provide opportunity to see the innovation being used Trial: Provide opportunity to try out the innovation
Level 2: Appropriate tasks for adoption phase (group)		
Mass Media Communication Channels are <u>not</u> integrated into the diffusion plan.	Mass Media Communication Channels are integrated into the diffusion plan, but <u>no</u> strategy for when the Mass Media Communication Channels should be used is provided.	Mass Media Communication Channels are integrated into the diffusion plan and a strategy for when the Mass Media Communication Channels should be used is provided. Use early-on to raise awareness and interest
Level 3: Adopter types, identify and use Early Adopters to influence others		
Adopter Types are <u>not</u> considered as part of the diffusion plan.	Adopter Types are considered as part of the diffusion plan, but there is <u>no</u> special focus on the use of Early Adopters.	Adopter Types are considered as part of the diffusion plan and there is special focus on the use of Early Adopters. Target early adopters for diffusion activities to influence non-Adopters Use Early Adopters to demonstrate the innovation to non-Adopters

Level 4: Use of interpersonal communication channels (social networks, opinion leaders)		
Opinion Leaders are <u>not</u> integrated into the diffusion plan.	Opinion Leaders are integrated into the diffusion plan, but <u>no</u> specific strategies of how to best use them is identified.	Opinion Leaders are integrated into the diffusion plan and specific strategies of how to best use them is identified. Target Opinion Leaders for diffusion activities Use Opinion Leaders to demonstrate the innovation
Social Networks are <u>not</u> integrated into the diffusion plan.	Social Networks are integrated into the diffusion plan, but <u>no</u> strategy for how to use the Social Networks effectively is provided.	Social Networks are integrated into the diffusion plan and a strategy for how to use the Social Networks effectively is provided. Target highly networked individuals who have a high degree of influence Indirectly target those who are in the interest/awareness phase (especially laggards) through their Interpersonal Communication Channels
Level 5: Use of formal leaders and gatekeepers		
Formal Leaders are <u>not</u> integrated into the diffusion plan.	Formal Leaders are integrated into the diffusion plan, but <u>no</u> strategy for how to best use them is identified.	Formal Leaders are integrated into the diffusion plan and a strategy for how to best use them is identified. Target Formal Leaders for diffusion activities Use Formal Leaders to demonstrate the innovation Do <u>not</u> use Formal Leaders to mandate adoption.
Gate Keepers are <u>not</u> integrated into the diffusion plan.		Gate Keepers are integrated into the diffusion plan.

Appendix F: Post-Interview Questions

Usability

What, if any, elements of the DSG's interface were initially confusing or unclear?

What, if any, suggestions do you have to make the DSG's interface more clear?

What, if any, game mechanics of the DSG were initially confusing or unclear?

What, if any, suggestions do you have to make the DSG's game mechanics more clear?

Appeal

What aspects of the DSG did you find engaging or appealing?

What aspects of the DSG did you find boring or unappealing?

What, if any, suggestions for how the DSG could be made more engaging or appealing?

Effectiveness

What aspects of the DSG did you find helpful for learning?

What aspects of the DSG did you feel hindered learning?

What, if any, suggestions for how the DSG could better promote its learning objectives?

Instructional Support

How useful did you find the content provided by the virtual mentor?

What, if any, suggestions do you have on improving the content provided by the virtual mentor?

Appendix G: Final Pre- and Post- Test Scoring Rubric

Level 1: Select and use appropriate tasks for adoption phase		
Adoption phases (equivalent to awareness, interest, and trial) are <u>not</u> integrated into the diffusion plan.	Adoption phases (equivalent to awareness, interest, and trial) are integrated into the diffusion plan, but appropriate activities are <u>not</u> identified for each phase.	Adoption phases are integrated into the diffusion plan along with diffusion activities that are appropriate for each phase. Awareness: Provide information about the innovation Interest: Provide opportunity to see the innovation being used Trial: Provide opportunity to try out the innovation
Level 2: Identify and use Early Adopters to influence others		
Adopter Types are <u>not</u> considered as part of the diffusion plan.	Adopter Types are considered as part of the diffusion plan, but there is <u>no</u> special focus on the use of Early Adopters (or of those with characteristics of Early Adopters).	Adopter Types are considered as part of the diffusion plan and there is special focus on the use of Early Adopters in one or more of the following ways. Target Early Adopters for diffusion activities to influence others. Use Early Adopters to demonstrate the innovation to non-Adopters
Level 3: Use of social networks to diffuse innovation more quickly		
Social Networks are <u>not</u> integrated into the diffusion plan.	Social Networks are integrated into the diffusion plan, but <u>no</u> strategy for how to use the Social Networks effectively is provided.	Social Networks are integrated into the diffusion plan and a strategy for how to use the Social Networks effectively is provided. Target highly networked individuals who have a high degree of influence Indirectly target those who are in the interest/awareness phase (especially laggards) through their Interpersonal Communication Channels

Appendix H: Solutions to Identified Issues in Round 1

O	1	2	3	4	Issues	Solutions
x					All lesson 1 objectives: “Select an Information or Diffusion Activity First” Error Message should not mention information activities because they have not yet been introduced.	Change message to say “Select a Diffusion Activity First”
	x	x	x		Objective 1: Player tries to click on deactivated activities. They are confused as to why they are not allowed to select them, or want to click on one but cannot.	Add mini-message when player clicks on a disabled activity to say something like “During the first objective, I am helping you by only allowing you to select appropriate activities”.
	x				Objective 1: Feedback messages for Observe Study and Observe Class are reversed	Switch them to be accurate
x					Objective 2 (Micah): player must repeat same activity 3 or 4 times to get through trial phase.	Reduce number of boxes in trial phase and add boxes to interest phase. Sorting activity will and probability graph will also help user understand that only one activity is appropriate for the trial phase.
	x	x	x	x	Despite mentor messages to address this, confusion caused when an appropriate activity does not work. Player is reinforced when an activity they select an activity that is not appropriate but still ends up working.	For objective 2 only - Provide the probability that an activity selected will be effective to reinforce that there is an element of randomness/chance/luck. Each activity is represented as a slice of the pie for the current phase of adoption: Red = ineffective Yellow = somewhat effective Green = very effective

x	x	x	x	Player does not realize they can repeat an activity or feels that it should not be effective.	<p>In objective 2: after the first time the player is unsuccessful from selecting an appropriate activity initiating an explanatory mini-message, add a follow-up mini-message stating that “You may, and sometimes need to, repeat the same activity.”</p> <p>Also in objective 2, at the bottom of the “success spinner”, add a note that states “You may use an activity multiple times.”</p>
	x	x		<p>In objective 2:</p> <p>Player categorizes activities incorrectly.</p> <p>Player does not understand concept of appropriate task selection. No justification being used.</p>	Create interactive activity for player to categorize diffusion activities into appropriate phases-of-adoption. Indicate to the player once they have correctly categorized the activities. Make this available via a button during objective 2 and add a mini-message to alert the player of the activity.
	x			In objective 2, player thinks they must continue with the same activity even after the mentor urges them to use something different.	<p>After 3 inappropriate choices, if the player has not completed the categorization activity, force them to do so.</p> <p><i>* if needed:</i></p> <p>After 5 (or more) force player to repeat categorization activity.</p>
	x	x		<p>In objective 3:</p> <p>Player categorizes activities incorrectly.</p> <p>Player does not understand concept of appropriate task selection and cannot progress.</p>	After 3 inappropriate choices, force player to complete the categorization activity. Upon completion, restart the player on the 3 rd objective.
x				In objective 3, Player must repeat same activity multiple times to	Reduce number of boxes in the interest phase.

				get through Interest phase.	
x	x	Players unclear as to what the objective is.		Provide description of the innovation as part of the objective.	*This is something I had planned to do but had not finished before data collection began.
	x	In objective 3, not clear if recommendation is to “see it in action” or “try it out”		Reword activity to align more with trial.	Also, make note of this in the objective description.
		x	Obj. 1: Not reading through entire mini-messages (1o, 1p, 1q) about why activities are effective for the current phase of adoption.		Bold the WHY part of the 1o, 1p, and 1q messages.
x	x	x	x	After completing objective 2, players confused with the message stating they had made no mistakes.	This issue will be alleviated by removing the messages which warned the player against their current activity selection.
x	x	Players are not noticing the calendar		Check that calendar lengths are appropriate for each objective.	Add number of weeks to the objective description.
	x	x	Players think something is wrong when boxes turn red.		Change red box to faded green
	x	Vertical scrollbar appearing on main game		Change height of panels	
	x	Scrollbars showing on Mentor Window, making the [RETURN TO GAME] button not		Resize Mentor Window and internal windows as needed. Use my netbook to test new dimensions.	

visible					
x				Did not realize game was disabled when mini-messages were showing.	Increase amount of white in fade from 0.5 to 0.6
x	x	x	x	Video plays twice	Fix to play only once
	x			Video slider is difficult to use (hard to move to a given spot)	Make slider full length of video with smaller tick intervals
	x			Video had much content to take in very quickly for players who are not as fluent with English.	If needed - Provide link to a text based version of the lesson
x				BUG: Video controller does not stay anchored to bottom of video	Re-anchor video controller by re-setting the controller's y-coordinate every time the Lesson buttons are pressed.
x		x		Quality of video is low (audio and text)	Republish the project for exact size. Do not resize in Flex.
x		x		Did not read Mentor Messages Found Mentor Messages unappealing (un-gamelike)	Tell player on the outset that the first level contains 3 objectives and there will be much guidance for the first objective. If needed - List all objectives with checks next to those that have been completed. Show an indication of how much the mentor will be helping next to each objective.
x	x	x	x	Not realizing that earlier messages can be reviewed. Not reviewing earlier messages.	No fix for now... players may not have a desire or need to review earlier messages.
		x		Loss of attention/focus by the end of video resulting in loss of key information. None of	Provide text-based version of the most important part Provide alternate ways of gaining the

the players reviewed the video – supportive information – even when they were lost or confused.	information: Text-based version of the lesson Bold key info of mini-messages Sorting activity
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** Items in red were not addressed prior to round 2 but may have been addressed later.*

** The first column identifies whether the issue was observed by the author while the next 4 columns identify which participant(s) discovered the issue.*

Appendix I: Solutions to Issues Identified in Round 6 and Potential Solutions

O	17	18	19	20	Issues	Solutions
	X				Not completing level 2, objective 2 despite making mostly good choices.	May need to add time to L2, Obj2
	X				Misunderstanding of the meaning of light and dark green squares.	Highlight the table cells to show each person's current phase of adoption.
	X				Players not returning to Mentor and/or not knowing how to get back to supportive information and their current and past objectives.	Add a mini-message? "Remember, you can always review your current and past objectives, video lessons, and mentor messages by clicking here."
	X	X			Players cognitive load is burdened due to not having information readily available.	Provide information (such as adopter type) in a persistent manner without need to roll-over.
	X				Confused when Lesson 3 appeared and therefore did not watch lesson 3 video (until I interrupted).	Do not enable the Begin button until the player presses the Play button of the Lesson 3 video. Do this in similar cases as well.
	X		X	X	Did not close the social network but instead tried to move it to the side. This caused other issues... such as horizontal scroll bar appearing... and the next social network replacing the first... and only getting one of the mini-messages that appear when the social diagram box is closed.	Use a transparent canvas to prevent player from clicking anywhere other than on the social network box. Make the transparent canvas disappear when player closes the social network box. Change the social network box so it is not draggable and set its coordinates so the box appears in an appropriate place on the screen.
	X	X			Difficult to complete L3, Obj1 in allotted time even on second attempt.	May need to add time to L3, Obj1

X			Typos on DSG 2.0 Beta 1. on detailed view of O, may need an “s” after “calling” 2. Description of N... should be “loves” instead of “lives”.	Alert Miguel
X			Felt there were too many pop-ups	
X			Beep is too loud in relation to the video	Reduce volume of beep or increase volume of videos.
X	X		Video Time shows 5:59 until the play button is pressed	Fix this by hardcoding the initial time
X			Felt Lesson 2 video was too long.	
X			Felt Lesson 3 video was too long.	Re-create Lesson 3
X	X		Text in Lesson 3 video is too small. Video controls cover up the text in the diagram.	Re-create Lesson 3
X			Suggestion I agree with to make adopter types in video persistent (just grayed out) so that player can look back and see they do add up to 100.	Re-create Lesson 3
X			L2, Obj2: Bug in Sort Activity... scrollbar appearing on person’s description for some people (e.g. dr. Yang).	
X	X	X	Bug: Feedback Id’s are showing.	Increase height of the box which the description appears to accommodate an extra line of text.
X			Player finds getting Personal Information on everybody tedious.	Add a “Get Personal Info on all remaining people” in which the cost is appropriate for the number of people remaining.

X			L2 Obj3: Wrap-up activity... drag and drop functionality not reacting well to movements.	I think this has been fixed but I had not uploaded the most current version. Check to be sure.
X			L3 Obj. 1: Information Activities did not appear until a refresh was done.	Fix bug.
X			L3 Obj. 1: Adopter Type roll-over icons not showing correctly in Detailed View.	Fix bug.
X			Thought red square signified something negative.	Recommend change to current version of DSG.
X	X	X	There is confusion as to which phase of adoption people are in, especially in cases where a character in the game has all squares filled in one phase and no square filled in the next.	Highlight the cell of the current phase of adoption for EACH character in the game. Do not rely on the boxes for this.
		X	Clicking on BACK button goes to previous objective.	Combine all objectives into one application with only one URL. Also, disable or hide the Back button if possible.
X		X	Players not reading the feedback carefully.	
X		X	Did not understand how to select appropriate activities.	Could include a Sort Activities in the initial objectives of level 2 and 3 as well.
		X	Desires a way to go back and see which activities have been effective	Enable the Log for training levels.

** The first column identifies whether the issue was observed by the author while the next 4 columns identify which participant(s) discovered the issue.*

Appendix J: Excerpt from Journal of Design Decisions

Objective	Design Decision	Design Expertise (Researcher and others)	4C/ID Model; Ten Steps to Complex Learning	Resources (Including Money and Time)	Consistency with the original design	Technical Ability and/or affordance of software	Findings from evaluation: usability testing	Knowledge of content (Diffusion of Innovations)	Improve Usability	Consistent with previous levels
1.2	Message 2d: Warning: wrong activity for trial phase	x							x	
1.2	Created new objective and new innovation (Xtreme Conditions paint)... task variation		x							
1.2	Created new activities and feedback messages... task variation		x							
1.2	Created feedback messages in which the rate of success correlates to the Early Adopter/Early Majority types				x					
1.2	Message 2e: Reminder that using an appropriate activity does not always result in positive results.	x								
1.2	Added indicator in feedback panel of "Number of Inappropriate Activities Used"	x								
1.2	Force player to redo task if inappropriate tasks were used		x							

	- require mastery before progression to next task.			
1.3	Created new objective and new innovation (diet plan)... task variation	x		
1.3	Created new activities and feedback messages... task variation	x		
1.3	Created feedback messages in which the rate of success correlates to the Early Adopter/Early Majority types		x	
1	Created Lesson 1 to provide supportive information (mental model needed to complete the tasks) - accessible at any time during the task	x		
1	Lesson 1: Used text, visuals, and audio in the lesson to increase engagement.	x		
1	Lesson 1: Explained phases of adoption from the Diffusion of Innovations theory and how it maps to the phases of adoption in the DSG		x	x

Appendix K: Reflections Made After Each Round of Formative Research

Round 1 Reflections

After each round, the author reflected on how well the 4C/ID Model and the Ten Steps to Complex Learning (TSCL) supported the instructional design of the game.

The first reflection made after Round 1 was a confirmation of the design decision that had been made to include information of how to play the game in a just-in-time fashion. The justification for providing the information of how to play the game in this way is that it is procedural in nature. Because the TSCL prescribes that all procedural information related to the content to be learned (the diffusion of innovations theory) should be provided in a just-in-time fashion to reduce cognitive load of learners, the author had anticipated that the procedural information related to how to play the game should be provided in the same manner. This method of delivering instruction was effective in informing players how to play the game without overwhelming them with too much information at once.

Another reflection about the 4C/ID Model in its application to the DSG relates to observations which revealed that participants never reviewed the supportive information (e.g. the instructional video) after having watched the videos the first time. This may be because players expect, or prefer, to learn through gameplay. The trial-and-error approach of learning through gameplay is more interactive than the video which was used to provide the supportive information. Alternatively, players may have felt they understood the supportive information and so did not need to review it. Whatever the reason may be for players not reviewing the supportive information, the 4C/ID Model may benefit from

providing players alternate methods of experiencing the supportive information; particularly in interactive ways.

In the case of the DSG, one strategy added after Round 1 for providing the supportive information to players in an interactive fashion was to provide them with sorting activities. The sorting activities were designed by following the recommendation of the TSCL in designing instruction by considering behaviors demonstrated in successful game sessions by more expert players. Because it was observed in previous studies that more successful players took notes and sorted individuals into categories based on their characteristics (especially those related to opinion leadership and openness to change), the Sort People activity in Level 2 was designed to encourage all players to employ this strategy. Similarly, in Level 1, the Sort Activities activity was designed to facilitate the sorting of diffusion activities into categories of Adoption Phases. As mentioned previously, both sorting activities are examples of part-task practice (one of the four components of the 4C/ID Model).

Another reflection about the TSCL in its application to the DSG is related to a need for interventions when learning does not occur as intended. What happens when a player is not learning the concepts which the game intends to deliver? What if players are unable to apply the concepts effectively to progress in the game? While the TSCL provides strategies for improving the quality of the instruction, an additional element may be appropriate for the TSCL to address this issue. In the case of the DSG, interventions were added in various ways. In objectives in which the Sort Activities activity was optional, the player was eventually forced to complete the activity after making a particular number of inappropriate activity selections. Likewise, corrective mini-messages were added to be presented to the player upon passing a certain threshold of errors.

Round 2 Reflections

After the second round, the author again made reflections on how well the 4C/ID Model and the TSCL supported the instructional design of the game. The first reflection was similar to a reflection made after Round 1. There appeared to be a need to have multiple methods for conveying the same information to support players with different learning styles or to repeat information that may have overlooked or forgotten. For example, players in the game generally read the majority of the mini-messages, but few thoroughly read the information provided in the feedback panel detailing the results of the diffusion activity they had just employed. Participant 6 commented on the large amount of text in the game saying “I think there was a heavy lean on the educational part... not as much on the game part. With a game I look for a lot more visual stimulus and there were a lot of words that were popping up at me.”

For players who do not attend to textual parts of the game that provide information that is important for learning and progression in the game, alternate methods for providing the information may be needed. This is consistent with the common strategy of game designers to “show, don’t tell.” The need for multiple pathways for learning the same content goes beyond the reflection made after Round 1 of providing information in interactive ways in that it includes not just the supportive information related to the content to be learned, but all procedural and supportive information related to the content and the gameplay. Elements such as the Probability Graph and the sorting activities were helpful in providing information to players in more interactive ways. After the Round 2 analysis, additional elements were added to provide information in supplemental ways. For example, the labels for awareness, interest, and trial were formatted to appear as links and modified to provide information about each phase when the player moused-over the links. Additional strategies for highlighting information were added after the third round of data

collection was completed as well; including the addition of visual elements (images of an ear, eyes, and a hand in 4.1.1.C) to bring attention and meaning to the types of activities appropriate for each phase of adoption (visible in 4.1.1.C) and the addition of the “KEY INFORMATION” button which provided the player with an alternate and quicker method of reviewing the mental map needed to complete the objectives of the current task class.

Another reflection made after Round 2 that may be useful in adapting the TSCL for its application to educational games is that gamers (those who regularly play games) and non-gamers (those who do not regularly play games) may approach games in different ways. Based on the observations, gamers try to break the rules of the game and do things in the game just to learn how the game internally operates. For example, Participant 6 was enough of a gamer to comfortably use game terminology (e.g., game mechanics and cut scene) in the interview responses. Upon starting the game, this participant almost immediately began repeating activities in a probing fashion and asking questions such as “is it random?” On the other hand, non-gamers may be more likely to follow the rules and even impose additional rules on themselves based on what they believe should be true in the real world. For example, Participant 5 self-reported that they did not play video games often outside of online poker and solitaire, both of which are typically familiar to players before they play virtually and therefore do not require a great deal of probing to understand the internal workings of the game. This participant’s approach to playing the game was influenced by their own preconceived notions of the terms introduced in the game. In the interview, the participant stated that “I had my own little definitions of brochure and demonstration and promo offer.” Instead of attempting to understand how the meaning of these activities relate to the game outcomes, the participant expected the game would respond in the way they believed it should according to their prior life experiences. Also, despite mini-messages stating that some activities would need to be

repeated, the participant had trouble adopting this notion. At one point during the game after having read multiple messages that activities could be repeated, the participant said “Oh, you can use [it] more than once... that’s right, that’s right.”

A reflection made after Round 2 which may be particularly useful in informing the application of the TSCL to educational games is that players had a desire and/or expectation of interactivity and animation. Players responded well to the colorful Probability Graph but preferred that it would be animated to spin. More so than the non-interactive instructional video, participants responded well to the interactive sorting activities which were provided as an alternate method of learning the same content that was in the videos.

A final reflection that was made after Round 2 was that providing the supportive information prior to any gameplay adds an additional cognitive load to players that may not be necessary. Often players were initially so focused on learning how to play the game that attention to the instructional content was diminished. A common feeling was articulated by participant 5 who stated “What hindered me from learning was me just trying to figure out the game” and “I think I was more focused on learning the game than on the information that was supposed to be learned.” If this issue proves to be common when applying the 4C/ID Model to other educational games, consideration of alternative strategies for alleviating the cognitive load during the epitome lesson may be appropriate.

How could the amount of information be reduced in players’ first interaction with the game? One strategy could be to post-pone the introduction of supportive information until after the player has become familiar with the game environment and learned the game mechanics. In the case of the DSG, this could involve the player completing the first objective (likely unsuccessfully) before being introduced to any instructional content. The supportive information could then be presented before the player attempts the same

objective again. If this method is used, almost all the mini-messages providing instruction of how to play the game could be removed on the second attempt and replaced by the supportive information related to applying the innovation diffusion concepts. Besides reducing cognitive load, this strategy may be effective because it provides the player with an experience to reflect on when the supportive information is introduced. The approach may also increase the appeal of the game because the player experience would begin with gameplay instead of instruction. Alternatively, this same strategy could be incorporated by having the player attempt the final objective of the game (the original DSG) once prior to beginning the less complex objectives of Level 1.

Providing supportive information until after the player has become familiar with the game environment is inconsistent with the framework of the 4C/ID Model in that it does not provide the supportive information (the mental model) which players need to be successful in completing the initial task prior to the learner attempting to complete the task. Likewise, having learners complete the last task (which has no instructional support) of the last task class (which involves the most complex tasks) is inconsistent with the theory and could result in cognitive overload. Despite the authors belief that the strategies described in the previous paragraph would likely promote learning, to stay true to the 4C/ID Model and the TSCL these solutions were not implemented into the re-design of the DSG.

Round 3 Reflections

A reflection made after analyzing the Round 3 data was a confirmation of the prescription of the TSCL to not increase the complexity of the task within a task class. Round 3 participants were presented with a fourth objective that increased in complexity — requiring players to persuade an entire group (not just a single person) to adopt an innovation. Though unintentional, including a more complex objective as the final

objective of the level was not consistent with the 4C/ID Model. Players did not perform well on the new objective. Participant 9, for example, commented that the game “suddenly looks overwhelming” upon seeing the fourth objective. The same participant could not figure out how to use an activity which required more than one person to be selected until the author interrupted to tell them to read the activity description more closely. Participant 8 had trouble understanding that the adoption points had to be awarded progressively through the phases of adoption and had to repeat the fourth objective after failing the first attempt. After Round 3, the multi-player objective was moved into Level 2 in which players were provided with a more developed mental model designed to support them in persuading a group of people to adopt an innovation.

A few players suggested that a non-interactive example of gameplay be provided in the video lesson which would include the reasoning behind game choices. For example, Participant 19 stated “Perhaps the virtual mentor could run through a scenario whilst providing commentary on the thinking involved in making choices.” This is consistent with the prescription of the TSCL to provide the learner with a worked-out example as the first task. This may have been a more effective approach for learning than providing players with an interactive worked-out example. However, this approach may also result in frustration from learners who expect to begin playing the game more quickly or who expect to learn through their gameplay. Participant 18 expressed this view, stating “I would suggest that the tutorial be made interactive in some way, rather than simply videos. I think I would have remembered better what the terms awareness, interest, trial, and adoption meant in the context of the theory if I had played a mini game to learn their meanings (or ‘build’ their meanings) instead of watching a video of them.”

The final thought recorded after Round 3 was not a reflection on the 4C/ID Model's application to games but instead related to how developed the Diffusion of Innovations theory was at the point in which the original game was designed. There had been a great deal of empirical research completed which informed the Diffusion of Innovations theory at the time the original board game version of the DSG was created. However, participants in the study continued to voice a strategy both in their pre-test and gameplay sessions which the Diffusion of Innovations theory did not include and which the DSG does not directly endorse. The strategy is simply to use incentives to help diffuse an innovation. Participant 8, for example, stated that "I will have to figure out some type of incentive" as they began the game. Four of the first nine participants also described the use of incentives for diffusing innovations in their pre- or post-test. Participant 8, for example, gave a strategy in the pre-test to "provide financial or other tangible incentives for villagers to consume boiled water." Participant 1 stated in their pre-test response that they would implement a rewards system. Participant 7 discussed both positive reinforcement ("a monetary stipend to everyone who joins and adopts the boiled water policy") and negative reinforcement ("if there is a relapse, the affected locals lose their stipend"). Extrinsic rewards may or may not be effective in diffusing innovations. However, many of the participants of this study believed that offering rewards would be an effective way to persuade people.

Round 4 Reflections

Reflections following Round 4 data collection again related to the application of the TSCL to the DSG. For instance, what happens if a player is able to complete an activity without meeting the learning objectives? Players may have completed the learning tasks successfully because they were lucky in their gameplay or because a different

understanding of how to be effective in their gameplay was successful. Allowing players to progress to more complex learning tasks before mastering the more simple tasks could result in confusion and frustration as the game becomes more difficult. In the DSG, this appeared to be the case for many players who did not grasp the difference between activities that were more appropriate for raising awareness and those which were more appropriate for raising interest. To resolve this gap in learning, many attempts were made to provide the information to the player at different times and in different ways, a wrap-up activity was added at the end of the lesson to review what should have been learned, and the Sort People activity which was not available in the final objective was made available for the player if they failed. Adapting the TSCL to ensure that learners master the concepts of each task class and do not just figure out how to beat the game without applying these concepts may be useful.

Another consideration that should be made when applying the TSCL to the design of educational games is in the fidelity of the game to real life. Most participants made comments about the games authenticity and often were unlikely to adopt concepts and information that were not consistent with their own real-life experiences. For example, participant 13 stated “The problem is that my experience is a little divergent from [the definitions of awareness and interest provided in the game]. I understand why the theory says that but in the practical world, once you’ve got people interested, you get them to do a hands-on; you literally just bring them to the issue.” Several participants made comments about activities they did not believe would be effective based on their own personal experiences. Participant 14, for example, stated “I’m really not a big fan of Infomercials and Reality TV” and accordingly initially avoided using these activities. Likewise, Participant 13 stated “Based on reliability, I have an inherent distrust of any Infomercial

that I see on TV because usually it's too good to be true, so as much as I dislike Reality TV as well, I am going to go with the Reality TV option because that at least shows real people, even though I know enough about TV production in the real world to know that Reality TV is not reality in any way, shape, or form."

The designer of any game which simulates the real world must be aware of the preconceptions that players will have and design the game in such a way that the players' beliefs which are inconsistent with the game do not distract the player from the learning objective. The designer should consider whether the content of the game is inaccurate and need to be changed; or the preconceptions are false beliefs which the game needs to challenge.

Round 5 Reflections

Consideration must be given to how accessible different information should be to the player. Providing too much information on the screen at one time appears to result in portions of that information being ignored. It was apparent through gameplay observation that many players did not read the feedback provided with the outcome of each activity. This feedback provided key information that could help the player realize which phase of adoption the selected activity is or is not appropriate for. The reason this was so often ignored may have been because there was too much text in the game in general or because they felt that focusing on other elements of the game would be more beneficial. Another reason this textual information might have been ignored was because the accompanying beeps and green squares may have been the dominant feedback which players attended to.

Another issue with providing information in a persistent manner is that there may be too much information to provide it all on the screen at once. This was true with the case of the DSG. Still, providing information in a persistent manner gives players the

easiest access to the information with the least risk of breaking their immersion into the game.

Requiring the player to click one or more times to open a new window to view information allows information to be removed from the game screen while making it accessible to the player when needed. However, players may not use this information for several reasons. They could forget that it is available; as in “out of sight, out of mind”. They may find that accessing the information repeatedly is too tedious. Even if players are willing to go through the steps required to access the information, they may lose focus on what they had been doing or thinking about in the game. Of course, the benefit is that information that is not regularly needed could be removed from the primary game environment to free up valuable screen real estate which can be used for the information that is more important or that players need access to more often.

A middle ground strategy for providing information is through the use of roll-over elements that provide information only when the player places their mouse over the element. This allows an indicator of the information to remain on the screen so the player does not forget it is there while also allowing them to access the information in a very simple way. This still requires a small amount of screen space for the roll-over element but not nearly as much as would be necessary if all the information was provided on the game screen. One risk of this approach is that players may not realize that they may mouse-over the element to get more information. This was sometimes the case in the re-designed DSG even when the roll-over elements were formatted to suggest interactive capabilities.

Another strategy to deal with information is to give users control as to how they want to access the information. This allows players the flexibility to set the game up in the

way they feel would best support their progress. As with all the strategies there are drawbacks to this as well. One drawback is that because the player is learning, they may not know which information is important and may not be able to judge which method is better for their learning and game performance. Another issue is that designing multiple methods for accessing the same information may require a significant amount of additional development work.

In the re-designed DSG, all of the strategies discussed above were used to present information. The instructional video and the sorting activities were made available to the player via a “Mentor” button that had to be clicked and opened over the top of the game screen. Descriptions of diffusion activities were provided within the game when the player moused-over the name of the activities. The adoption points, current phase of adoption, and the calendar were all provided in a persistent way to the player (displayed on the game screen at all times). User control was provided to players through a “List View” and a “Detailed View”. The “List View” made it possible to show all names of the people and their adoption points at once while requiring the player to mouse-over the information icons to read the personal information of each individual. The “Detailed View” provided the additional personal information of each individual in a persistent manner on the screen. For the few objectives involving many people, this resulted in a need for players to scroll in order to see all the individuals.

In reflecting on the TSCL, it may be useful to include a set of heuristics which would help the designer determine how to present different types of information in the game. The guidelines could include concepts such as the required frequency in which the information would need to be accessed and how the information, which needs to be accessed more or less frequently, should be presented to reduce the cognitive load of

learners. At the very least, providing a description of the benefits and drawbacks of the strategies for providing information would be useful to novice designers.

Round 6 Reflections

Reflections about the final version of the game and, in particular, the applicability of the TSCL to the re-design of the game were made following the final round of Formative Research in the same manner as was done in all previous rounds.

Related to the overwhelming effect of large amounts of text which commonly resulted in information being overlooked, the author reflected on how the TSCL could be adapted to further reduce the cognitive load of players. Observations and participants' comments led to one potential addition to the theory. Cognitive load will likely be reduced by providing information which is frequently needed in a persistent manner (the information remains on screen at all times); avoiding the use of pop-ups and rollovers as a method for reviewing frequently used information. For example, instead of showing an Adopter Type icon for the user to roll-over to see a person's Adopter Type, the icon could have the letters which identify their Adopter Type (I, EA, EM, LM, L). Alternatively, information that is needed less frequently should not be persistently viewable to the player. With information that players need to access less frequently, the use of pop-up windows and rollovers are likely to be more appropriate. Additionally, some players rely on information that other players do not find necessary. In this case, the player should have control as to whether or not the information is persistently viewable.

Another reflection resulting from gameplay observations and participant comments is that players experience some frustration when the supports they find useful are taken away. Where it is possible to leave the instructional supports without diminishing learning, the supports should remain. For example, players should be able to sort the

diffusion activities into appropriate Adoption Phases, and sort people into appropriate Adopter Types, in all objectives. Though the activity should remain, the corrective feedback should be faded because learners will not always have this guidance in real-world tasks. Alternatively, as a few participants suggested, players may benefit from having the ability to highlight or tag people to categorize them into groups.

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Edutainment Systems LLC (*January 2010 – December 2012*)
Instructional Designer, Programmer

- o Developed game engine, game editor, character customizer, and language library for a series of adventure games designed to improve literacy of children.

Indiana University, Bloomington IN (*August 2007-July 2011*)
Distance Education Graduate Assistant

- o Support IST Faculty in Distance Course Management
- o Update IST Department Website

Associate Instructor

- o Taught R347/F500: Impact of Games & Simulations in Instruction
- o Taught W200 Lab: Technology in Instruction
- o Taught X101: Learning Strategies for Math

Director of Bell and Beyond (after school technology program)

- o Supervised pre-service teachers at three elementary schools

Ivy Tech Community College, Bloomington IN (*January 2009-June 2009*)
Adjunct Instructor

- o Taught PHP and MySQL
- o Taught Adobe Flash and AS3

Capistrano Valley USD, Mission Viejo CA (*August 2006-July 2007*)
Mathematics Instructor

- o Taught Algebra I, accelerated Algebra II/Trigonometry

Newport-Mesa USD, Costa Mesa CA (*February 2002-July 2006*)
Mathematics & Computer Science Instructor

- o Taught 7th grade skills, pre-Algebra, and Algebra, ELD 1 Algebra
- o Taught 7th and 8th grade Computer Applications and journalism class

Blue Valley USD, Stillwell KS (*July 2000-August 2001*)
Computer Science Instructor

- o Taught Visual Basic, Advanced Visual Basic, C++, Advanced C++, and Technology Literacy
- o Supervised students designing Blue Valley High School web page

<http://www.seriousgamegroup.com/portfolio>

RESEARCH PUBLICATIONS

Enfield, J., Myers, R., Lara, M., & Frick, T. (2012). Innovation Diffusion: Assessment of strategies within the Diffusion Simulation Game. *Simulation & Gaming Journal*. 43(2), 188-214.

Ke, F., Yildirim, N., & Enfield, J. (2012) Exploring the design of game enjoyment through the perspectives of novice game developers. *International Journal of Gaming and Computer-Mediated Simulation*, 4 (4).

CONFERENCE PRESENTATIONS

Enfield, J. (2011). *Application of the 4C/ID Model to the Re-design of the Diffusion Simulation Game*. The Annual Meeting of the Association for the Educational Communications and Technology, Jacksonville FL.

Enfield, J., Myers, R., Wu, T., Kwon, S., & Frick, T. (2011). *Approaches to studying online games for learning*. The Annual Meeting of the Association for the Educational Communications and Technology, Jacksonville FL.

Yildirim, N., Enfield, J., & Ke, F. (2011). *Exploring the Key Factors of Game Design Process: Player Enjoyment*. Games, Learning, & Society Conference, Madison WI.

Lara, M., Enfield, J., Myers, R., & Frick, T. (2011). *Learning Assessment in the Diffusion Simulation Game*. The Annual Meeting of the American Educational Research Association, New Orleans LA.

Dutta, P. & Enfield, J. (2011). *Design Jams for Instructional Designers*. Instructional Systems Technology Conference, Bloomington IN.

Enfield, J. (2010). *Developing games for free: A case study*. The Annual Meeting of the Association for the Educational Communications and Technology, Anaheim CA.

Lara, M., Enfield, J., Myers, R., & Frick, T. (2010). *Assessing learning in online simulations: A case study of the Diffusion Simulation Game*. The Annual Meeting of the Association for the Educational Communications and Technology, Anaheim CA.

Myers, R., Enfield, J., Lara, M., & Frick, T. (2010). *Analyzing gameplay data to improve the design of a simulation game*. The Annual Meeting of the Association for the Educational Communications and Technology, Anaheim CA.

Enfield, J. & Myers, R. (2010). *Assessment of strategies within the Diffusion Simulation Game*. Games, Learning, & Society Conference, Madison WI.

Enfield, J. (2010). *Developing games for free: A case study*. Association for the Advancement of Computing in Education Global Learn Conference, Penang Malaysia.

Enfield, J. (2010). *Smuthie.com: create, blend, and share: An experiment in social collaboration through art, music, and animation*. Association for the Advancement of Computing in Education Global Learn Conference, Penang Malaysia.