

## **A Design Case: Creating an Enhanced Version of the Diffusion Simulation Game**

Miguel Lara, Rodney Myers, Theodore Frick, Sinem Karabacak Aslan, and Theodora Michaelidou

*Department of Instructional Systems Technology, School of Education, Indiana University Bloomington*

In this paper, we describe the design case for creating a new online version of the Diffusion Simulation Game (DSG). Originally a board game (Molenda & Rice, 1979) and then an online version (Frick, Ludwig, Kim, & Huang, 2003), the new DSG was rapidly prototyped first on paper and then in Flex Builder, ActionScript, PHP and MySQL. We also report results of play-tests, usability evaluations, and how the design and implementation of the DSG has been improved.

### **Overview**

The purpose of the Diffusion Simulation Game (DSG) is to learn change management strategies which are consistent with Roger's (1995, 2003) diffusion of innovation theory and related research in this area. The goal of the DSG is to promote acquisition of strategies that result in adoption of an innovation (peer tutoring) by the principal, teachers and support staff at a fictional junior high school. The DSG models: progressive stages of awareness, interest, appraisal and trial of the innovation that precede adoption by individuals; people who are innovators, early adopters, early majority, late majority, and laggards; and those who are opinion leaders and gatekeepers. Game activities include gathering information on potential adopters; viewing diagrams of networks portraying school committees, lunch mates, and socializing outside of school; talking to individual staff members; asking help; making site visits; providing a demonstration of the innovation; conducting workshops; use of mass media; confrontation; and compulsion.

The challenge to the DSG player, who takes the role of a change agent, is to get as many individuals as possible to adopt the innovation. Each diffusion activity takes from 1 to 5 weeks of virtual time, and the game ends when either 72 weeks elapse or all teachers and the principal become adopters. By repeated play of the DSG, a user is expected to learn which diffusion strategies are effective with whom and when, depending on the adopter type and each person's changing stages of adoption when appropriate strategies are chosen that work with that person. It takes about two hours to play the DSG the first time, and about an hour for each successive play. The DSG also models stochastically the probabilities of success for various diffusion activities. Sometimes an activity succeeds and other times it does not, depending on the current game state, probabilities of success of the activity for various adopter types and stages of adoption, and chance. If used as part of a course—after students have played the DSG multiple times outside of class—the DSG includes a printed summary of key ideas from Roger's theory and change management for discussion during a debriefing session.

The DSG has been successfully used in a board game format for several decades in the Instructional Systems Technology master's program at Indiana University Bloomington. In 2002, the third author led a team of graduate students to build the first online version of the DSG, which has been used regularly in the distance master's program (cf. Frick et al., 2003).

Requests for DSG licenses for use outside of our university have been growing. Starting in the fall 2008, we have been designing and developing an enhanced version of the DSG that will: 1) store logs for successive game plays, reviewable by students and their instructors; 2) make it easy to insert new content for different settings (e.g., in business, other languages); 3) make it easier to maintain, grant licenses and collect license fees; 4) link game play to a new record keeping system to facilitate research on strategies players use and how well they learn; 5) add levels of difficulty to the game; and 6) improve the interface to increase ease of use. In addition to applying van Merriënboer's (2007) 4C/ID model for design, we are creating the new DSG in Flex Builder, ActionScript and MySQL so that it will run over the Web but feel like a desktop application.

### **The Importance of Diffusion of Innovation Theory**

Innovation is the process of transforming an opportunity into new ideas with the goal to improve existing products, practices, or services (dal Zotto & Van Kranenburg, 2008). Notwithstanding the overall positive impact that an innovation might have within a specific context, there will invariably be people reluctant to adopt it (Burkman, 1987). This is mainly due to the fact that most innovations do not diffuse by themselves but require change agents and the willingness of potential users to change their preexisting mental models and behaviors.

“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). Diffusion of innovation theory explains the process by which new ideas and practices spread between and within social systems (Valente & Davis, 1999). Nowadays, multiple disciplines offer courses related to change management and diffusion of innovations as part of their curriculum to provide students the knowledge and skills needed when dealing with the implementation of new concepts and practices as part of their profession.

### **Purpose**

The purpose of this paper is to describe the process of designing a new online version of the DSG to overcome several limitations of the previous version; among the new version improvements are: storing interaction sequences in order to assess improvement in gaining adopters across repeated play; storing game logs reviewable by students and their instructors; making it easier to insert new content for different settings (e.g., in business, other languages); making it easier to maintain, grant licenses and collect license fees; adding levels of difficulty to the game; and improving the interface to increase ease and speed of use.

### **Methods**

#### **Participants**

A team of five graduate students in the Instructional Systems Technology (IST) graduate program at a large midwestern university led by the third author collaborated in the design and development process of the DSG enhanced version. The third author had previously led another research group in the design and development of the first DSG online version (Frick et al., 2003).

#### **Design Procedure**

Weekly meetings were held during a semester. Besides the meetings, the team members used emails and a listserv for communication. A Google site was eventually created to keep track of all of the decisions made during the design process.

The first meetings were entirely devoted to becoming familiar with the previous DSG versions. One session consisted of playing the board version; this session was led by Dr. Molenda, one of the original creators of the game, who also answered questions about the original design.

In subsequent meetings, the team members use brainstorming to identify a list of limitations of the previous online version and desired enhancements. This list was then used to define goals for the new enhanced DSG version. The goals were classified in two different categories:

- 1) Front-end (user interface):
  - Improve the interface to increase ease of use, reducing the amount of scrolling and mouse clicks needed to play the game and eliminating the need to refresh the page.
  - Improve the feel and look, making it more visually appealing.
  - Add licensing interface.
- 2) Back-end
  - Store logs for successive game plays, reviewable by students and their instructors.
  - Make it easy to insert new content for different settings (e.g., in business, other languages).
  - Link game play to a new record keeping system to facilitate research on strategies players use and how well they learn.
  - Add levels of difficulty to the game.

Once the expectations were identified, in the subsequent sessions the team dealt with two issues simultaneously, each of them taking approximately half of each session: the software to be used for the entire project and the user interface (UI) prototype.

Regarding the software to be used, the team decided that the front-end would consist of SWF files created in the Adobe open source program called Flex 3; for the back-end it was decided to use a combination of PHP (a server-based scripting language) and MySQL (a relational database management system).

The reason for using Flex 3 was that most Web browsers nowadays support Adobe Flash player which can play SWF movies. An alternate solution was to use AJAX (asynchronous JavaScript and XML), a group of

technologies that can be used to create Web applications that do not require the browser to refresh the page; however, the team realized that there are some issues related to browser and platform compatibility with AJAX. Moreover, the learning curve to configure and start using Flex was perceived to be smaller than AJAX, allowing a faster pace in the development of the application.

Concerning the UI design, several paper and digital prototypes were first created. Based on those prototypes, the team decided to use the concept of an “Activity Area” (Figure 1) in which the player would drag and drop a specific diffusion activity along with the staff members selected. Feedback about the player’s actions would also be displayed in this area. This prototype helped us to visualize all the different sections needed in the game and assisted us in determining the best way to integrate all of them. The team quickly decided that a drag-and-drop interface was less efficient than simply clicking desired components to select them.

Comparing the paper prototype to the first online version of the DSG (Figure 2) it can be noticed that the prototype followed a similar layout, using three different tabs to contain each of the three different main sections of the game, which are:

- 1) Game Rules, which includes the directions and objectives of the game;
- 2) Play Game, which includes the simulation game itself;
- 3) Game Logs, which includes the list of diffusion activities and staff members selected by the player during each turn.

The paper prototype (Figure 1) shows the content of the “Play Game” tab. This tab also kept a similar layout as the first online version: the calendar section remained at the top and the staff member list on the left, while the activity list was moved to the bottom. The main difference between the prototypes and the DSG first online version was the introduction of the “Activity Area” section.

**The Diffusion Simulation Game**

Adopters: [Calendar: Sep, Oct, Nov, Dec, Jan, Feb, Mar, Apr, May, Jun, Sep, Oct, Nov, Dec, Jan, Feb, Mar, Apr, May, Jun]

STAFF MEMBER	AWARDS- HSG	INTEREST	TRAIN/ APPEAL	ADOPTION
A PRINCIPAL	<input type="checkbox"/>	□□□□	□□□□	<input type="checkbox"/>
B SECRETARY	<input type="checkbox"/>	□□□□		<input type="checkbox"/>
C JANITOR	<input type="checkbox"/>	□□□□		<input type="checkbox"/>
D MATH CHAIRMAN	<input type="checkbox"/>	□□□□	□□□□	<input type="checkbox"/>
E MATH TEACHER	<input checked="" type="checkbox"/>	□□□□□	□□□□□	<input type="checkbox"/>
F MATH TEACHER	<input type="checkbox"/>	□□□	□□□	<input type="checkbox"/>

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**Activity Area:**

1. drag an Information Activity OR a Diffusion Activity here.
2. Then drag Staff Members here to participate.

**DIFFUSION ACTIVITIES**

TALK TO	ASK HELP	PILOT TEST	SITE VISIT	PRINT	PRESENTATION	DEAD
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**INFORMATION ACTIVITIES**

PERSONAL	LUNCH-MATES	COMMITTEES	SOCIAL	WORKSHOP (SOLF)	WORKSHOP (PROP)	INTERVALS WORKSHOP	LOCAL AWSS MEETING	CONVULSION	CONFRONTATION
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Figure 1. Example of DSG paper prototype.

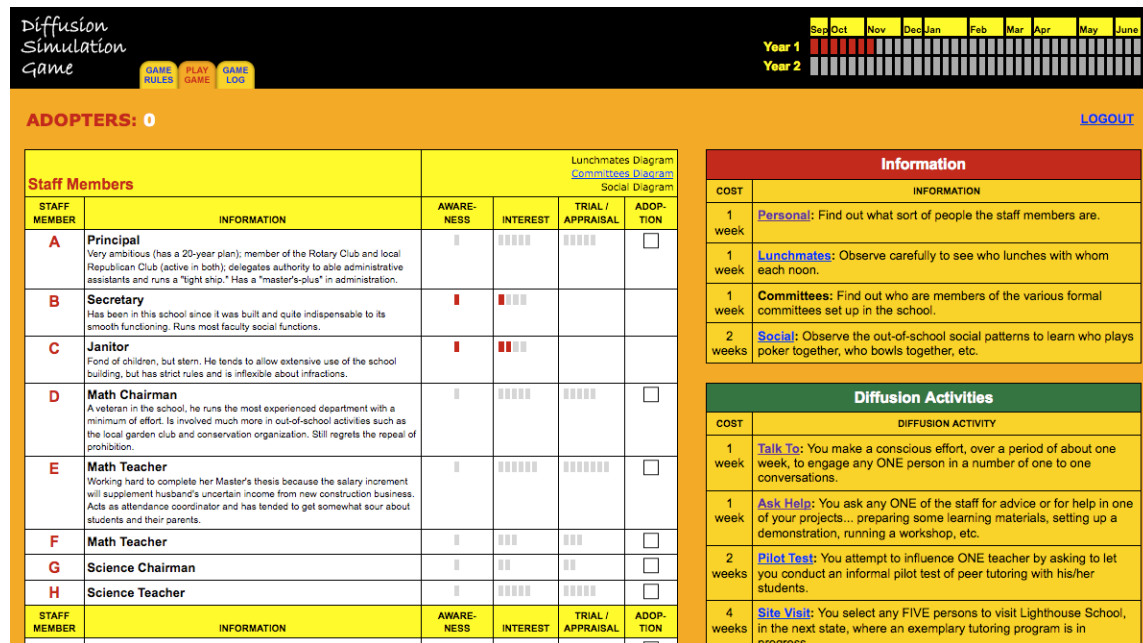


Figure 2. DSG first online version.



Figure 3. First digital prototype.

Corry, Frick and Hansen (1997) highlight the importance of focusing on the user throughout the design and development processes. An essential objective in the design of the enhanced online version of the DSG was to provide a better user experience. After a deeper analysis of the paper prototype, the team realized that placing the diffusion activities near the bottom of the screen created the potential disadvantage of players having to scroll down every time they needed to select an activity. For this reason, the team decided to have all the activities listed one below the other, on the right side of the activity area.

At this point, the team had already made the decision to use Flex for the User Interface. Since Flex facilitates rapid prototyping (Tripp & Bichelmeyer, 1990), the team decided to use it to create the first digital prototype that would include the modifications suggested from the paper prototype (Figure 3).

The first digital prototype helped the team to have a clearer idea about the monitor resolution that would be needed to fit as many of the game elements as possible in a single screen. A monitor resolution of 1024 x 768 was the most appropriate to diminish the amount of vertical scrolling while preventing horizontal scrolling at the same time.

Even though the first digital prototype was not fully functional, designers were able to emulate playing the game by selecting diffusion activities and staff members. Through this interaction, designers noticed that players would need to move the mouse from one side of the monitor to the other for every single turn in the game. Designers also realized that the natural order of the “Activity” and “Staff members” sections were inverted because players need to first select an Information or Diffusion Activity and then select up to five staff members.

Based on these observations, the designers switched these sections and placed them next to each other to match the sequence of decision making. Furthermore, since players of the first online version would continue playing in the new version, the designers decided to keep a similar background color as the first version. All these changes are shown in Figure 4.

The UI design process was very iterative; as soon as a change was done, all designers accessed the prototype and analyzed the revisions (even though the game was not functional yet). During team meetings, the designers commented about their observations and new changes were decided based on a team consensus.

After several weeks of work on the UI, the team agreed upon the design shown in Figure 5. In this final design the diffusion activity section is located at the left, followed by the staff member section, following the natural left-to-right reading process (as mentioned above, players need to first select a diffusion activity and then the desired staff members).

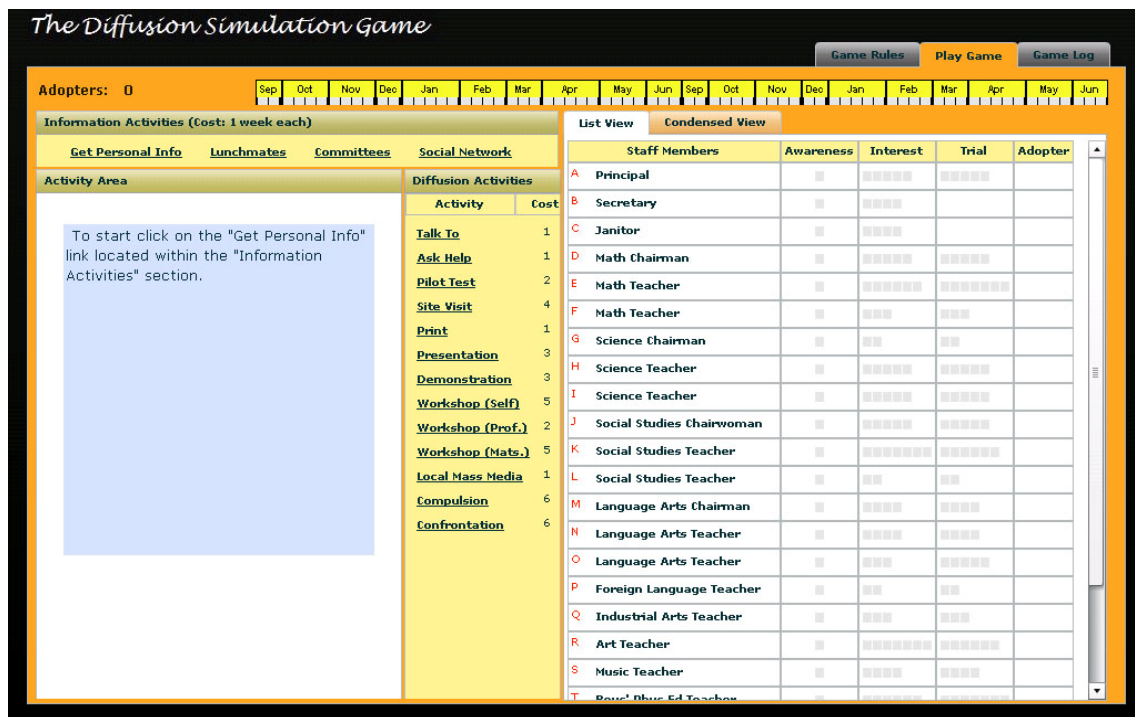


Figure 4. Second digital prototype.

The designers recognized the importance of reducing the short-term memory load as a golden rule of interface design (Shneiderman & Plaisant, 2005). However, this golden rule defied the rule about minimizing the amount of scrolling as much as possible. For purposes of the game, a player has to get the personal information of each staff member. Displaying all this information all of the time results in excessive vertical scrolling. The solution we proposed was to have two views: 1) a *list* view showing only staff member job titles along with a “tooltip” (call out) containing each staff member’s description whenever the mouse hovers over the job title; and 2) a *detailed* view, that shows each staff member’s complete description (only if “Get Personal Info” is true for him or her).



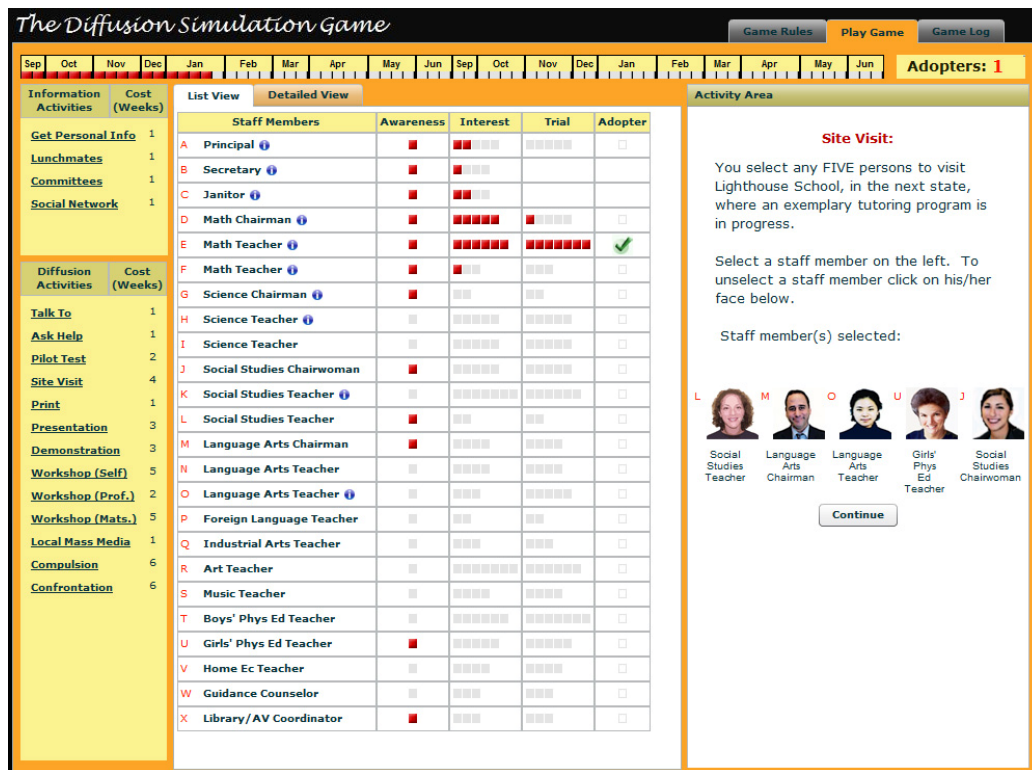


Figure 5. Final digital prototype: List View.

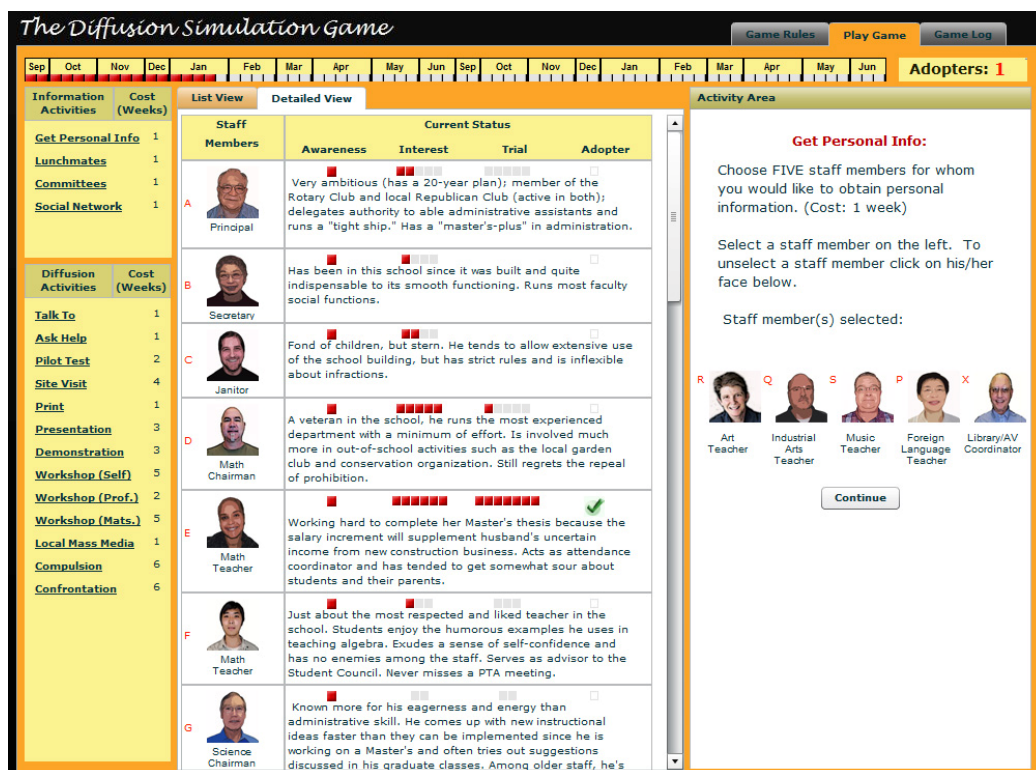


Figure 6. Final digital prototype: Detailed View

Moreover, the designers also decided to add more graphics, including the face of each of the staff members for the players to associate with a person's title, to make the game more appealing. The first set of faces was created

using an online commercial product called SitePal which specializes in the design of virtual avatars. However, for the release version of the new online game, the designers have decided to use cartoon (posterized) versions of pictures from real faculty, staff and students. The faces of the staff members along with their personal description are included under the “Detailed View” (Figure 6).

In conjunction with the UI design of the “Play Game” tab contents, a designer started working on the design of the “Game Rules” tab. Simultaneous work on the UI of both tabs was possible thanks to the use of Flex components, which are modular and easily combined into the final application.

In the first online version, the “Game Rules” tab consists of a single page. Given the goal of reducing scrolling, the designers decided to divide the content into five different subsections, each being displayed after clicking on the corresponding button on the left side of the screen (Figure 7).

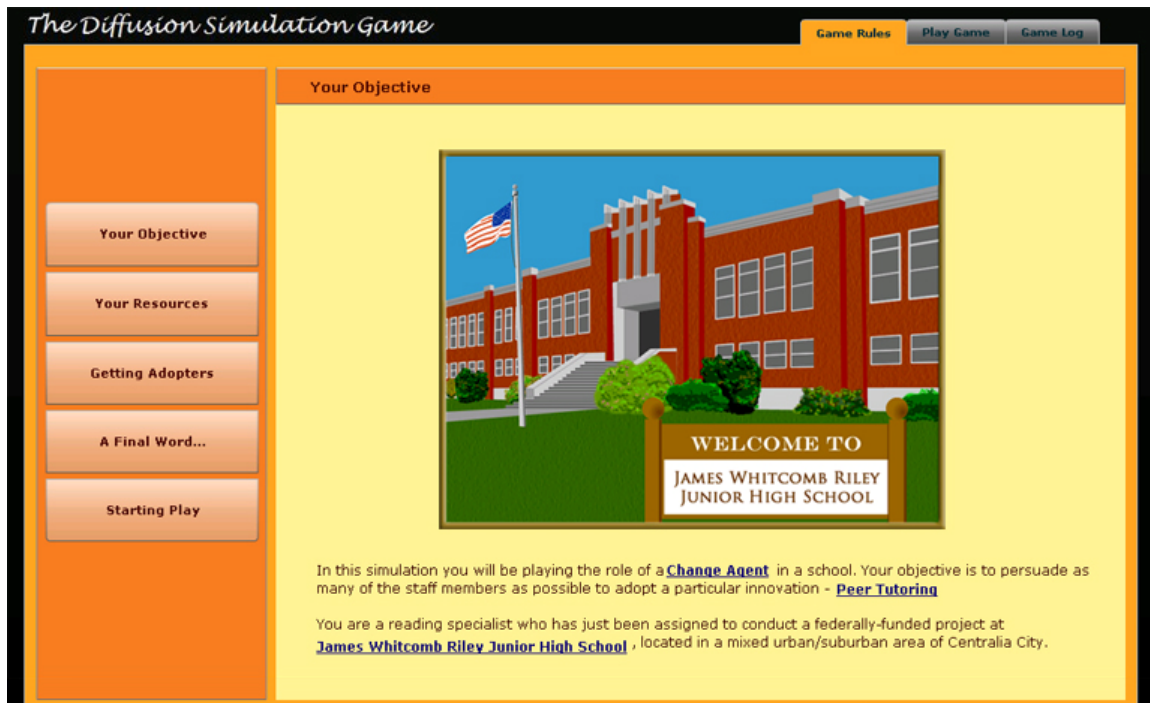


Figure 7. Final digital prototype: Game Rules tab

## Back-end Development

Once the UI design was completed, the designers created the database structure using an Entity-Relationship approach that would allow to: 1) store logs for successive game plays 2) make it easy to insert new content for different settings and languages 3) make it easier to maintain, grant licenses and collect license fees; and 4) add levels of difficulty to the game. The database used was the open-source DBMS MySQL. It was chosen mainly because most designers were already familiar with it and they were certain that it was going to handle the data to be stored without any issues. Furthermore, this database was already being used for other projects within the department and there was no need to install a new database server.

The designers used the Model-View-Controller architecture for the development of the DSG. The model consisted of model objects using PHP, the view consisted of the Flex user interface, and the controller consisted of the ActionScript programs and their corresponding calls to PHP programs which ultimately communicated with the database to retrieve and store data.

In order to be able to determine if learning is promoted by playing the game, the designers analyzed the player-game interactions that needed to be collected as evidence for assessment. This process of identifying relevant interactions and creating mechanisms to collect and store data is similar to the “information trail” suggested by Loh (2008). The designers then plan to use MAPSAT methods (Frick, Myers, Thompson, & York., 2008) to analyze the data gathered to determine the presence of patterns in the strategies used that result in either gaining many adopters (expert play) or few adopters (novice play).

## Usability Testing

**Testers.** The designers used convenience sampling to recruit the testers for the usability testing. A total of seven persons were recruited: six of them were female and one male. Three of the females were doctoral students in different areas in the School of Education. Most of the participants were Americans except for two who were from Turkey.

Requirements in recruiting testers were:

- 1) They should not have played any version of the DSG before.
- 2) They should not be familiar with diffusion of innovation theories.

The usability tests were conducted on an individual basis, with each designer taking the role of observer while a tester was playing the game. Testers were encouraged to use their own computers or laptops to avoid any disadvantages resulting from using unfamiliar technology (one-button mouse, operating system, etc.). They were informed that the usability test could take up to two hours and that they could take as many breaks as they needed during that time. They were also asked to think aloud (Preece et al., 1994) while playing the game. They were not helped during the game unless it was absolutely necessary.

There were no specific questions or tasks that testers had to complete during the usability test. They were only asked to play the game and to think aloud as they interacted with the game. The observer took notes and occasionally prompted the tester to think aloud while playing.

After completing the game, the testers were asked the following questions:

- Was it difficult for you to play the game?
- Was it difficult for you to navigate in the game?
- What would you do differently if you were to play the game again?
- Is there anything you would suggest to improve your game experience?

**Usability test results.** After completing all usability tests, the designers met and discussed their findings. Each designer described the issues or problems that the testers had as they were playing the game. For each issue or problem identified, the rest of the designers confirmed if they had experienced something similar. A list of the issues along with the number of times it was observed across multiple tests was created. The list of issues was then grouped into two categories: game mechanics and user interface.

Game mechanics:

- Testers needed to invest five to ten minutes to understand the rules of the game.
- Testers were uncertain about which staff members had become adopters.
- Testers assumed that they would be allowed to select personal information for only five staff members during the entire game instead of during a single turn.

User interface:

- Some game sections were unnoticed by the testers such as “Detailed View” and “Game Logs.”
- Testers were not always sure which staff received points (did not see red boxes get filled when points were awarded after reading feedback).
- Testers wondered if it cost one week each time they clicked on the link to see a diagram.
- Feedback contains letters to refer to staff members, but users were not sure what their role is without looking to the left and possibly scrolling.
- Some testers did not know what a “Home Ec Teacher” is.
- Testers wanted to display more than one diagram at a time but could not.

Regarding the game mechanics issues identified, it is worth mentioning that usability testers were not given any information about the diffusion of innovation theory before playing the game. This might be unrealistic in real game play because some of the players who will access the game most likely would have already studied the theory. Nevertheless, these findings clearly expose a strong weakness in the game: it takes too long for players to understand the directions and objectives of the game. Potential players could be easily discouraged from playing the game if this issue is not addressed. Alternative solutions consist of revising the Game Rules section to provide a clearer and more streamlined version of the directions; adding just-in-time information in the game interface; providing hints on an as-needed basis, based on the player’s interaction; creating a concise video tutorial.

The user interface issues detected made the designers realize the usefulness of usability testing as an ongoing part of the design process. Addressing the issues detected by the testers will help to improve the game’s usability.



## Future Work

So far, the designers have completed the front-end and back-end design of the DSG v. 2.0. The usability testing conducted was mainly to test the front-end—i.e., the interactions of the players with the UI. The back-end stores information about all of these interactions, allowing players to resume their games.

The next task is to recruit more testers to play multiple games and to analyze the data collected using MAPSAT (Map & Analyze Patterns & Structures Across Time) to verify if learning about the implementation of effective diffusion strategies is actually occurring. Version 2 of the DSG will allow us to conduct further research about student learning while playing the game. Measuring whether or not learning is occurring through playing educational games or simulations can be challenging (Bredemeier & Greenblatt, 1982; Dempsey, Rasmussen, & Lucassen, 1996; Hays, 2006; cf. Thiagarajan, 2003). In the case of the DSG, if the total number of adopters obtained by the same student across multiple game plays has increased, we are assuming that some kind of learning has occurred. Whether this learning is consistent with Roger's theory of diffusion of innovations is something that we plan to investigate. We intend to do this by use of MAPSAT to study patterns of diffusion activities chosen by players who are highly successful ("experts" who get everyone or nearly everyone to adopt) compared with players who only get some of the adopters ("non-experts").

Given the flexibility in the new back-end design, future DSG versions will include different levels of difficulty and multiple language support; we are also exploring the possibility of creating a version using a business context.

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