

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

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In this paper, we present a design case describing the creation of a new online version of the Diffusion Simulation Game (DSG). The DSG is a serious game that teaches change management strategies aligned with Rogers' (2003) diffusion of innovations theory. The goal of the game is to promote the understanding of strategies that result in the adoption of an instructional innovation by the staff members of a fictional junior high school. The original board version of the game was created in the 1970s (Molenda & Rice, 1979) and was played as part of a course in the School of Education of a large Midwestern university. The first online version of the game was developed in 2002 to provide access for students in the new distance master's program (Frick, Kim, Ludwig, & Huang, 2003). In order to overcome some of the limitations of the first online version, a new online version of the DSG was developed. This new version was rapidly prototyped first on paper and then in Flex Builder, ActionScript, PHP and MySQL. The design team used a rapid prototype approach (Tripp & Bichelmeyer, 1990) to iteratively design the user interface. In addition to describing the design process and rationale for design decisions, we also report results of play-tests and usability evaluations of seven recruited participants and how the information collected from these evaluations will help us to improve the current design.

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### Description of the Game

The Diffusion Simulation Game (DSG) teaches change management strategies which are consistent with Rogers' (2003) diffusion of innovation theory and related research. The player's goal within the DSG is to promote the acquisition of strategies that result in the adoption of an instructional innovation (peer tutoring) by the principal, teachers, and support staff at a fictional junior high school. The underlying model of the DSG represents several concepts of the diffusion of innovations theory such as: progressive adoption stages (awareness, interest, appraisal and trial, and adoption of the innovation), adopter types (innovators, early adopters, early majority, late majority, and laggards), opinion leaders, and gatekeepers. The player has the choice of selecting several different strategies, each having different efficacy at different times in the game. The player may choose to *gather information*, *talk to people*, *ask for help*, *conduct a site visit*, or *do a demonstration*, among others. Some of these activities require the user to make further choices. For example, players must choose who they will talk to, or which network – committee, lunch or social – they will view.

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 one to five weeks of virtual time, and the game ends when either 72 weeks elapse or all teachers and the principal become adopters. Through repeated play of the DSG, a user is expected to learn which diffusion strategies are effective for the various adopter types at each successive stage of their decision process. 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 Rogers' theory and other change management literature for discussion during a debriefing session.

### 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 with the knowledge and skills needed when dealing with the implementation of new concepts and practices as part of their profession.

### **Historical Success of the Game**

The DSG has been used successfully 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 (Frick et al., 2003).

Requests for DSG licenses for use outside of our university have been growing. Starting in the fall of 2008, we have been designing and developing an enhanced version of the DSG that will

- 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);
- make it easier to maintain, grant licenses and collect license fees;
- 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; and
- improve the interface to increase ease of use.

In addition to applying van Merriënboer and Kirschner's (2007) 4C/ID model for design, we are creating the new DSG using Flex Builder, ActionScript and MySQL so that it will run over the Web but feel like a desktop application in that it will not require repeated page loading as the first online version did.

### **The Purpose of this Paper**

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. The new version improvements include

- 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.

By presenting this design case, we hope to participate in the ongoing dialogue among those who design games for learning and to contribute to the bank of precedent from which those designers draw knowledge and inspiration.

## The Design

### Design Team

A team of five graduate students in the Instructional Systems Technology (IST) graduate program at Indiana 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 team of graduate students in the design and development of the first DSG online version (Frick et al., 2003).

### Design Procedure

The design team held weekly meetings during the first semester of work. In addition to these meetings, the team members used emails and a listserv for communication. The team eventually created a website hosted by Google 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 creators of the original game, who also answered questions about the original design.

In subsequent meetings, the team members used brainstorming to identify a list of limitations of the previous online version and desired enhancements. We then used the list to define goals for the new enhanced DSG version. The goals were classified into two categories as shown in Table 1.

Table 1  
*Design Goals for the New DSG*

Front-end (user interface)	Back-end
<ul style="list-style-type: none"> <li>• 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.</li> <li>• Improve the look and feel, making it more visually</li> </ul>	<ul style="list-style-type: none"> <li>• Store logs for successive game plays, reviewable by students and their instructors.</li> <li>• Make it easy to insert new content for different settings (e.g., in business, other languages).</li> <li>• Link game play to a new record</li> </ul>

appealing. <ul style="list-style-type: none"> <li>• Add a licensing interface.</li> </ul>	keeping system to facilitate research on strategies players use and how well they learn. <ul style="list-style-type: none"> <li>• Add levels of difficulty to the game.</li> </ul>
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Once the goals were identified, the team dealt with two issues simultaneously, 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 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 support the 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 were 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, some team members created several paper and digital prototypes based on some initial sketches. Based on those prototypes, the team decided to use the concept of an “Activity Area” 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.

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.

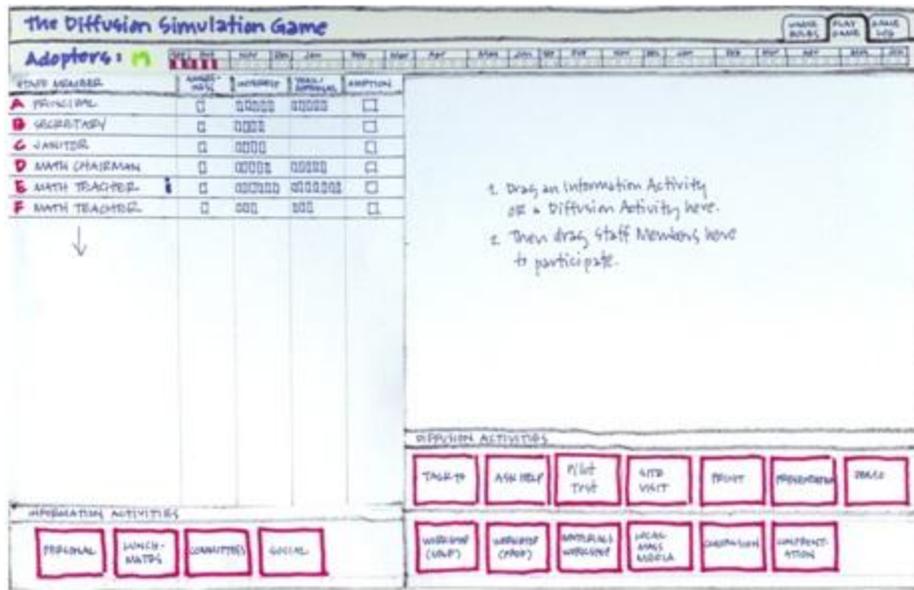


Figure 1. Example of DSG paper prototype.

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

- *Game Rules* includes the directions and objectives of the game.
- *Play Game* includes the simulation game itself.
- *Game Logs* includes the list of diffusion activities and staff members selected by the player during each turn.

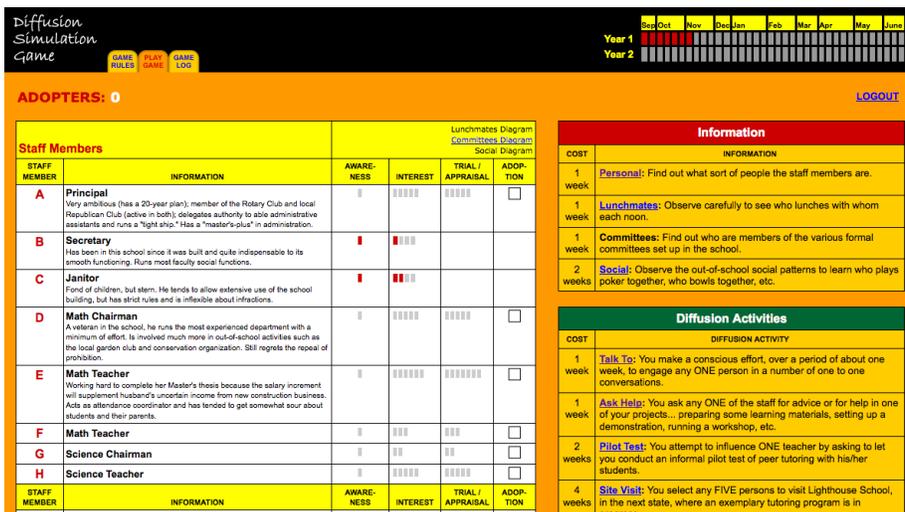


Figure 2. DSG first online version.

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 problem of being completely missed by players not using their browsers in a full window. An additional disadvantage was that players had to scroll down every time they needed to select an activity. For these reasons, 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 based on its ability to facilitate rapid prototyping. The team created the first digital prototype that would include the modifications suggested from the paper prototype (Figure 3).



Figure 3. First digital prototype of the new version.

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 reduce 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 in the game. 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.



Figure 4. Second digital prototype.

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 shared 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 information activity and diffusion activity sections are 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).

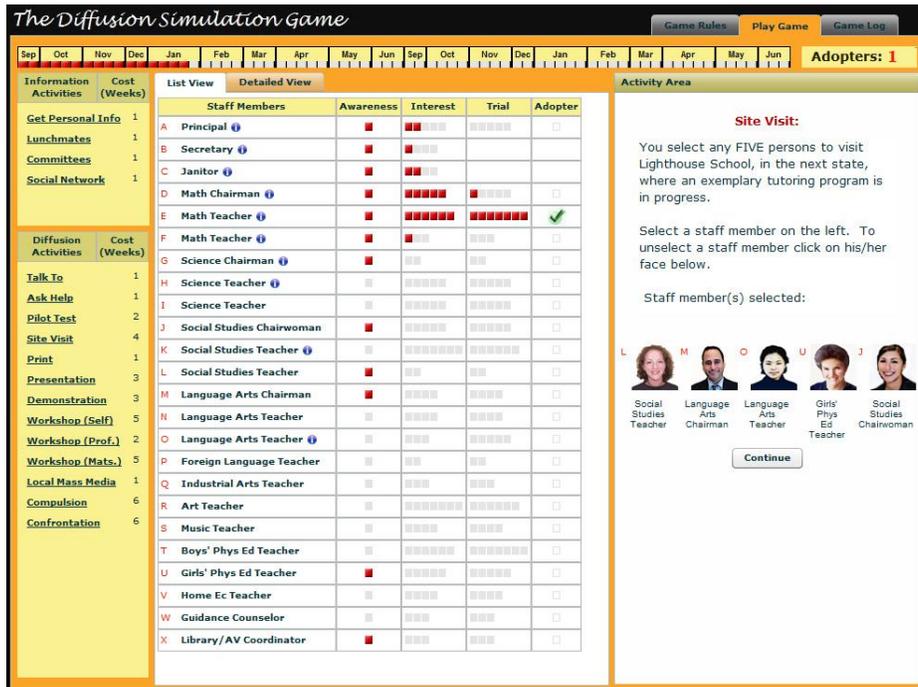


Figure 5. Final digital prototype

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 implemented 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* showing each staff member’s complete description (only if “Get Personal Info” is true for him or her) as shown in Figure 6.

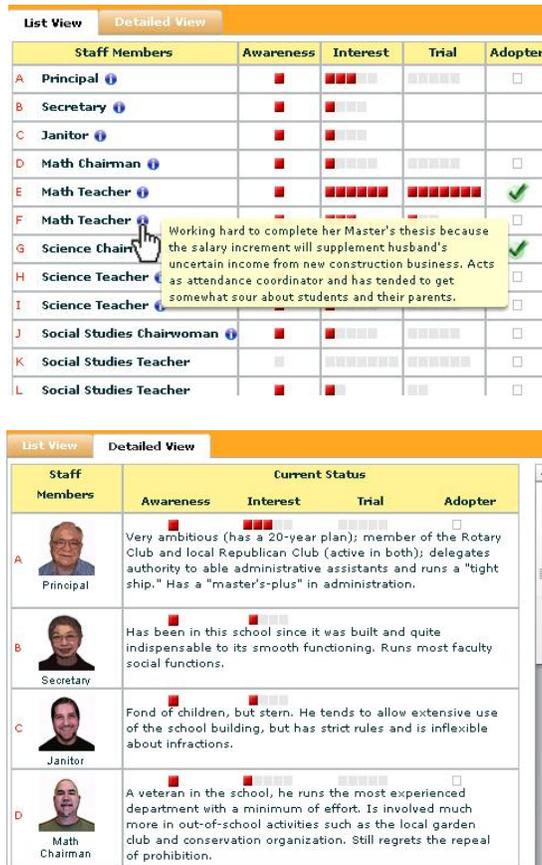


Figure 6. List View (top) and Detailed View (bottom).

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 and engaging. 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 decided to use cartoon (posterized) versions of pictures from real faculty, staff and students as shown in Figure 7.



Figure 7. Posterized pictures used in the game.

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 8).

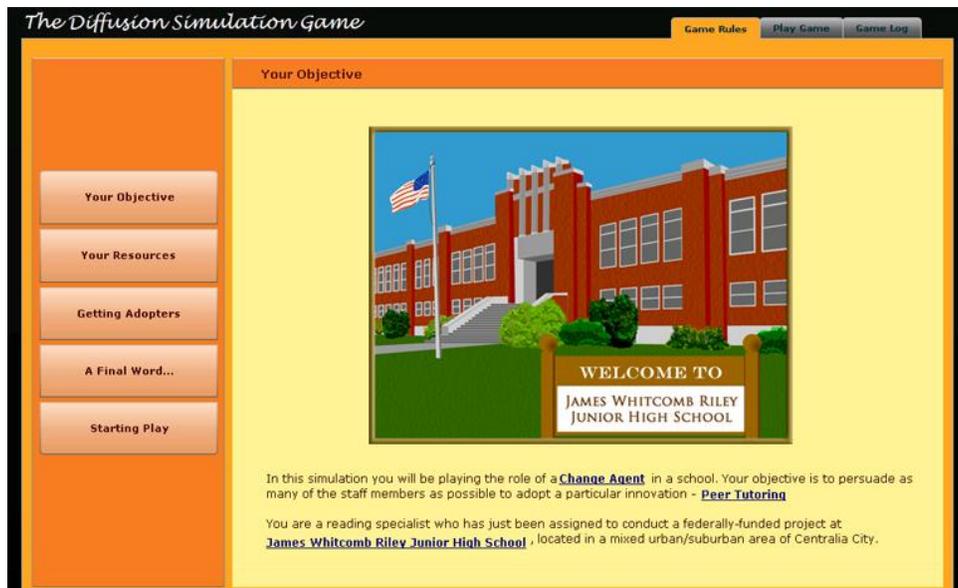


Figure 8. Final digital prototype: Game Rules tab

### Back-end Development

Once the UI design was completed, the designers created the database structure using an Entity-Relationship approach that would allow to:

- store logs for successive game plays;

- make it easy to insert new content for different settings and languages;
- make it easier to maintain, grant licenses and collect license fees; and
- 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.

## **Usability Testing**

### *Testers*

The designers used convenience sampling to recruit the testers for the usability testing. A total of seven testers were recruited, six female and one male. Three of the females were doctoral students in different areas in the School of Education. Five of the testers were Americans and the other two were Turks. To be recruited as testers, they should not have played any version of the DSG nor should be familiar with diffusion of innovations theories.

The usability tests were conducted on an individual basis, with each designer at a time 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 (Boling & Frick, 1997; 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 when playing the game. For each issue or problem identified, the rest of the designers confirmed whether they had observed 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 as shown in Table 2.

Table 2  
*DSG Issues Observed through Usability Testing*

Game mechanics	User interface
<ul style="list-style-type: none"> <li>• Testers needed to invest five to ten minutes to understand the rules of the game.</li> <li>• Testers were uncertain about which staff members had become adopters.</li> <li>• 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.</li> </ul>	<ul style="list-style-type: none"> <li>• Some game sections were unnoticed by the testers such as “Detailed View” and “Game Logs.”</li> <li>• Testers were not always sure which staff received points (did not see red boxes get filled when points were awarded after reading feedback).</li> <li>• Testers wondered if it cost one week each time they clicked on the link to see a diagram.</li> <li>• 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.</li> <li>• Some testers did not know what a “Home Ec Teacher” is.</li> <li>• Testers wanted to display more than one diagram at a time but could not.</li> </ul>

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 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 include 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.

### 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) tools (Frick et al., 2008) 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 Rogers' theory of diffusion of innovations is something that we are currently investigating. 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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