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Innovation Diffusion: Assessment of Strategies Within the DIFFUSION SIMULATION GAME

Jacob Enfield[1], Rodney D. Myers[1], Miguel Lara[1], and Theodore W. Frick[1]

Abstract

Educators increasingly view the high level of engagement and experiential learning offered by games as a means to promote learning. However, as with any designed learning experience, player experiences should provide an accurate representation of content to be learned. In this study, the authors investigated the DIFFUSION SIMULATION GAME (DSG) to assess the consistency of strategies effective in the game with those implied to be effective by the diffusion of innovations theory on which the game is based. They analyzed records from 2,361 completed game sessions of the DSG and compared successful and unsuccessful strategies. They further compared successful gameplay strategies with strategies suggested by the diffusion of innovations theory. The data analysis indicated that four of the seven winning strategies were inconsistent with what the theory predicts. However, this conclusion is tentative, given limitations of temporal detail in available data. These limitations imply how data should be collected to better investigate strategies that result in successful DSG gameplay. In addition, the study provides a case in which objective methods were used to analyze patterns of gameplay and offers insight on how data should be collected to analyze patterns more effectively.

Keywords

adoption of innovations, analysis of patterns in time (APT), assessment of strategies, change management, diffusion of innovations, education, fidelity, learning, representation accuracy, serious games, simulation games, theory-based simulation, web-based simulation

[1]Indiana University, Bloomington, USA

Corresponding Author:
Jacob Enfield, Indiana University, 951 Copper Beech Way Apt. C, Bloomington, IN 47403, USA
Email: jwenfiel@indiana.edu

Research on the use of simulations and games for learning has been increasing. For example, Rutter and Bryce (2006) compared the periods of 1995-1999 and 2000-2004 and found nearly twice as many peer-reviewed articles on digital games during the latter period. Bragge, Thavikulwat, and Töyli (2010) also provide some evidence that research on games and simulations may be increasing. They analyzed 2,096 articles that were published over the past 40 years in an established, peer-reviewed journal (*Simulation & Gaming*) and found that the percentage of research articles to nonresearch articles published increased from 38% in 1970 to 71% in 2008. Still, much of the reporting on the use of games for learning is anecdotal, descriptive, or judgmental; it is neither strongly tied to theory nor based firmly on rigorous research methods (Gredler, 2004; Kirriemuir & McFarlane, 2004; Leemkuil, de Jong, & Ootes, 2000; Washbush & Gosen, 2001; Wideman et al., 2007). Therefore, one goal of this study is to show how more rigorous research methods may be used to evaluate gameplay.

Another concern regarding educational games, and specifically games that use the manipulation of a simulation as a learning strategy, is fidelity. Fidelity is the degree to which a simulation is faithful to what it simulates. Many types of fidelity exist, but this study focuses on the accuracy with which the underlying computational model of a simulation game represents the theory it is designed to teach.

The purpose of this study was to investigate the fidelity of the DIFFUSION SIMULATION GAME (DSG) to Rogers's (2003) theory of the diffusion of innovations by testing the alignment of successful strategies within the game with strategies that are recommended by the theory to be successful. Specifically, the following research questions were addressed:

1. What strategies were successful within the game sessions being studied?
2. Were the successful strategies within the game aligned with strategies that would be predicted by the diffusion of innovations theory?
3. Did other successful game strategies exist that did not relate to the theory of the diffusion of innovations?

Furthermore, the study provided a sample case in which rigorous, objective research methods were used to study player interactions within a digital game.

Review of the Literature

Theory of the Diffusion of Innovations

"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's model for the diffusion of innovations, developed in 1962, consists of five phases that an individual (or other decision-making unit) experiences in the adoption of an innovation.

1. 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.
2. 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 toward the innovation.
3. 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.
4. 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 *reinvention* —the modification of the innovation to some degree.
5. Last, in the **confirmation phase**, the individual seeks reinforcement of the innovation decision he or she has made.

Communication channels are an important part of the definition of diffusion. "A communication channel is the means by which messages get from one individual to another" (Rogers, 2003, p. 18). Communication channels can be categorized as mass media channels or interpersonal channels. Mass media channels allow messages to reach large audiences. Interpersonal channels, on the other hand, involve direct exchange between two or more individuals.

Opinion leaders are members of the social system who influence others. They are at the center of interpersonal communication networks and, compared with their followers, are typically more exposed to external forms of communication, have somewhat higher socioeconomic status, and are more innovative (Rogers, 2003). The most effective opinion leaders are able to influence other individuals' attitudes and behaviors with a relatively high frequency.

Rogers (2003) categorizes all members of a social network based on their innovativeness—the degree to which an individual adopts new ideas earlier than other members in the system. From the most to least innovative, these ***adopter types*** are (a) *innovators*, (b) *early adopters*, (c) *early majority*, (d*) late majority*, and (e) *laggards*. By the means used by Rogers to develop his classifications, innovators account for 2.5% of the population, early adopters for 13.5%, early majority for 34%, late majority for 34%, and laggards for 16%.

Each of the five categories represents individuals who are likely to have specific characteristics and values. **Innovators** are typically venturesome and able to cope with a high degree of uncertainty when adopting something new. Due to rash decisions, they occasionally have setbacks when new ideas prove unsuccessful. **Early adopters** are typically respected for their discrete use of new ideas and therefore their higher rate of success. They often have the highest degree of opinion leadership and are often good targets for change agents who wish to speed up the diffusion process. 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. The **late majority** tend to be skeptical and often adopt due to peer pressure or as an economic necessity. Finally the **laggards** are typically traditional in nature and the last to adopt an innovation. They possess almost no opinion leadership and often have little interaction with others. Decisions by laggards are mostly influenced by the past, and they are typically suspicious of innovations and of change agents.

Change agents purposefully influence the innovation decisions of members of a social system in a direction deemed desirable by a change agency (Rogers, 2003). Typically, change agents wish to speed up the process by which innovations are adopted. They need to identify the adopter types of individuals, the opinion leaders within the group, and the communication channels that exist to be effective in facilitating the diffusion of an innovation. Rogers (2003) offers generalizations, with evidence from previous diffusion studies to support each, which suggest that

> Change agents' success in securing the adoption of innovations by clients is positively related to (1) the extent of change agent's effort in contacting clients, (2) a client orientation, rather than a change agency orientation, (3) the degree to which a diffusion program is compatible with clients' needs, (4) the change agent's empathy with clients, (5) his or her homophily with clients, (6) credibility in the clients' eyes, (7) the extent to which he or she works through opinion leaders, and (8) increasing clients' ability to evaluate innovations. (p. 400)

The theory of diffusion of innovations is useful in understanding how a change agent can effectively introduce and facilitate the adoption of an innovation. Core concepts that a change agent should be aware of include phases of adoption, adopter types, mass media and interpersonal communication channels, role of opinion leaders, and the change agent's own relationship to the group.

Fidelity of Simulations

Fidelity refers to the accuracy with which a simulation represents reality. Fidelity may be examined in terms of the simulation's presentation (perceptual fidelity), the interaction of the components (functional fidelity), and the underlying model (model fidelity; Alessi, 2000; Alessi & Trollip, 2001; Gibbons, McConkie, Seo, & Wiley, 2009; Reigeluth & Schwartz, 1989). In terms of Alessi and Trollip's (2001) taxonomy for fidelity analysis, the DSG is a *situational simulation* because it represents human behavior, which is complex and difficult to model with high fidelity. In this case, it is important to provide a variety of user actions and feedback that is consistent with both the information provided and behavioral theory (Kuppers & Lenhard, 2005).

The literature on simulation design refers to the assurance of model fidelity as *verification and validation*. Validation is intended to ensure that the conceptual model is consistent with the real world, whereas verification is intended to ensure that the computational model is consistent with the conceptual model (Pace, 2004). The goal of verifying the underlying computational model is to provide evidence that it is sufficiently accurate for its intended use (Sargent, 2008; Thacker et al., 2004). In this study, the conceptual model is Rogers's (2003) diffusion of innovations theory, which has undergone 50 years of refinement and validation; the computational model is the program logic of the DSG, which has never been formally verified.

Simulation designers often use a combination of techniques for model verification, with the primary techniques being structured walk-throughs and traces (Sargent, 2008). We examined the fidelity of the simulation's computational model by collecting and analyzing the results of players' interactions with that model and comparing those results with what is predicted by Rogers's model to be effective in the real world.

Description of the DSG

The original DSG was developed in 1975-76 at Indiana University by an Instructional Development Center team composed of professor Michael Molenda and six IST graduate students, led by Patricia Young and Dale Johnson. The original DSG was a board game played for decades by students in instructional systems technology (IST) at Indiana University (IU) who were learning about change management. An online version of the game was developed in 2002 for the distance program which contains a guide for instructor debriefing via asynchronous discussion after the DSG has been played by students. A free version was made available in 2006 for unlicensed use. It provides no gameplay logs for user inspection, no unique login names or debriefing guide, but is otherwise identical.

The DSG is a simulation game in which the player takes on the role of a change agent in a junior high school. The goal of the game is to facilitate the understanding of the diffusion of innovations theory. The player's objective is to persuade as many of the 22 staff members as possible to adopt an innovation—peer tutoring. To be effective, players must learn appropriate application and sequencing of available diffusion strategies.

The primary game mechanic of the DSG is the selection of diffusion activities used to persuade staff members to adopt the innovation. The diffusion activities (*Talk To*, *Ask Help*, *Pilot Test*, *Site Visit*, *Print*, *Presentation*, *Demonstration*, *Self-Administered Workshop*, *Professional Workshop*, *Workshop to Develop Materials*, *Local Mass Media*, *Compulsion*, and *Confrontation*) each cost the player a different number of weeks to complete and have varying impact on staff at different times in the game. In addition, using high-risk activities such as *Compulsion* and *Confrontation* may have detrimental consequences and could even result in the immediate end of the game. Descriptions of each activity are shown on the game screen, as displayed in Figure 1. The description

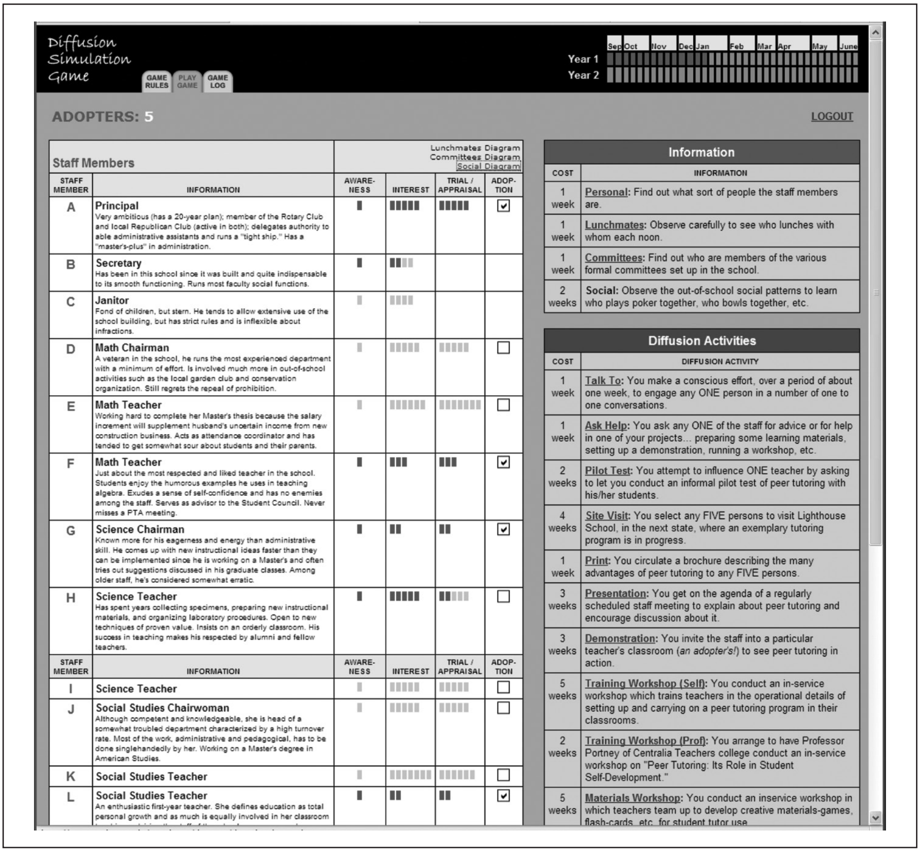

Figure 1. Screen capture of the DSG (v1) in progress
Note: DSG = DIFFUSION SIMULATION GAME.

of the *Print* activity, for example, reads "You circulate a brochure describing the many advantages of peer tutoring to any FIVE persons." With only a 2-year academic calendar to complete the diffusion process, selecting the most efficient diffusion activities at the appropriate time in the game is crucial to winning the game.

Players also have access to *Personal Information* on individual staff members (represented in the game by a letter and title, e.g., "A: Principal") and diagrams of the interpersonal communication networks that exist (*Lunchmates*, *Committees*, and *Social Groups*, for example, Figures 2 and 3). This information can be used to determine which staff members to include in the selected diffusion activities. Some staff members are well connected and influential. Therefore, in addition to selecting activities, selecting appropriate staff members for those activities is a critical part of a player's strategy.

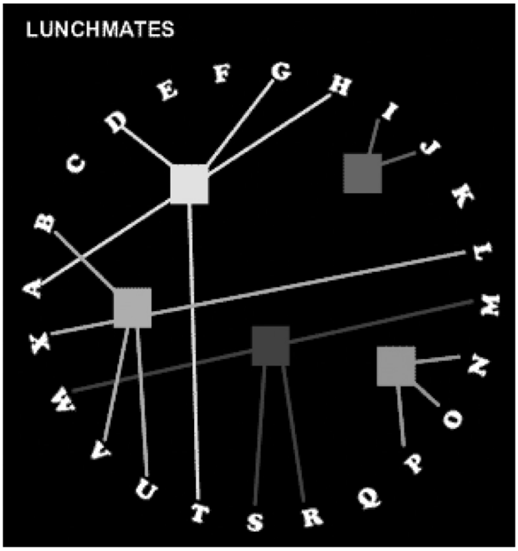

Figure 2. Illustration of the lunchmates network diagram from the DSG
Note: DSG = DIFFUSION SIMULATION GAME.

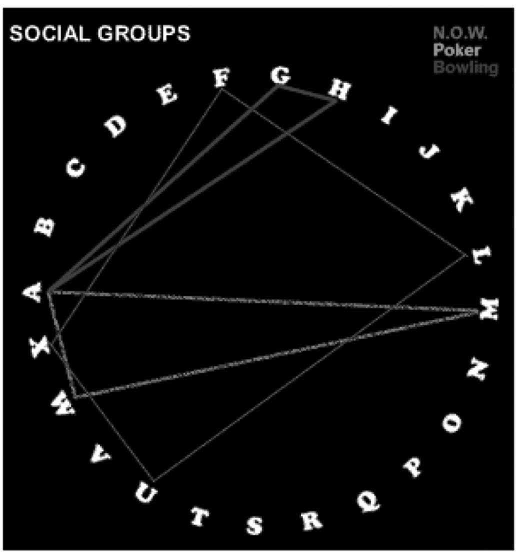

Figure 3. Illustration of the social groups network diagram from the DSG
Note: DSG = DIFFUSION SIMULATION GAME.

To get staff members to become adopters, the player must advance them through the adoption stages of *awareness, interest,* and *trial/appraisal.* The ***awareness*** stage in the game correlates to the knowledge phase of the innovation-decision process discussed previously. Similarly, the ***interest*** stage correlates to the persuasion phase and the ***trial/appraisal*** stage to the decision phase. For each staff member, a variable number of boxes exist for each of these phases that represent how far along the staff member is in the innovation-decision process. In addition to clues in their *Personal information,* the number of boxes for each staff member provides further evidence as to what adopter type he or she is likely to be: *innovator, early adopter, early majority, late majority, or laggard*.

Strategies That Should be Successful in the DSG

This section identifies strategies formulated by the authors that should be successful given the context of the DSG. These strategies are based on our own understanding of the diffusion of innovations theory. This is a potential bias for the study. Note however that all of the authors have studied the diffusion of innovations theory and one of the authors is a professor in IST, who has taught about the diffusion of innovations theory for many years and has been involved with the design and development of the DSG since the online version was conceived. Rogers's (2003) generalizations about the effectiveness of change agents discussed previously give insight into some of these strategies. We formed other strategies from additional aspects of the diffusion of innovations theory such as communication channels and adopter types.

One of Rogers's (2003) generalizations suggests that the change agent should take a client-oriented approach by building rapport with staff and increasing his/her credibility in the eyes of the staff. To develop a strategy around this generalization, a player should "get to know" the staff by reading the *Personal Information* available, using *Talk To*, and examining the communication channels in their interpersonal networks to identify the interrelationships among the staff. A client-oriented approach also suggests that the change agent should be empathetic with clients. This logic leads to a second strategy of avoiding *Compulsion* and *Confrontation* to persuade individuals to adopt the innovation.

Based on the generalization that change agents should work through opinion leaders, an effective strategy in the game should be involving the opinion leaders in effective diffusion activities early on. Although the opinion leaders are not labeled explicitly, *Personal Information* provided about staff members offers clues needed to identify them. For example, information on one math teacher states:

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

This description includes clues that indicate this teacher is an opinion leader and has influence over other staff members, students, and parents in the system. By persuading the opinion leaders to adopt the innovation early on, the change agent will indirectly influence other staff members who would then be more likely to become adopters.

Another of Rogers's (2003) generalizations suggests that the change agent should increase the staff members' ability to evaluate the innovation. To do this, players should select activities that allow staff members to see the innovation in use—*Pilot Test*, *Site Visit*, and *Demonstration*.

Selecting the appropriate communication channels for staff is another strategy that should be successful in the game. For staff members who are not aware of the innovation, mass media communication channels are helpful in making many aware of the innovation quickly.

> Mass media channels are means of transmitting messages that involve a mass medium such as radio, television, newspapers, and so on that enable a source of one or a few individuals to reach an audience of many (Rogers, 2003, p. 217).

Because all staff members are unaware of the innovation at the beginning of the game, activities such as *Print* and *Local Mass Media* should be effective early in the game in making staff members aware of the innovation.

As staff members progress past the awareness stage, interpersonal communication channels become more important than mass media communication channels. Besides working through opinion leaders, players may also work with staff members who have the most interpersonal connections. For example, based on the three interpersonal network diagrams in the game, one of the social studies teachers does not eat lunch with other staff, serves on no committees, and has no social network. Persuading this staff member will most likely have little influence on other staff members. However, one of the science teachers has two other staff members in his social network, regularly has lunch with four staff members, and is on two committees with a total of 11 different teachers. This teacher has many interpersonal communication channels and could be highly influential. Not surprisingly, this teacher is one of the three opinion leaders in the game. Such teachers who are both respected and highly connected should have the most influence on other staff members.

Players may also consider the adopter type of each of the staff members. Although adopter types are not made explicit, *Personal Information* about staff members offer clues to which category each staff member belongs. For instance, the science chairman's information reads:

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

This implies that he is most likely an innovator and not an opinion leader.

The diffusion of innovations theory proposes that early adopters have the most influence within a system. Due to their discrete, successful use of innovations and high degree of respect from others, early adopters are often the opinion leaders in a system. Therefore, another strategy that should be successful is to frequently target early adopters for diffusion activities.

To use this strategy, players must first identify early adopters among the staff. In addition to clues within *Personal Information*, the number of boxes an individual has in the adoption phases is an indicator of his or her adopter type. For example, with a total of only five boxes, the social studies teacher (L) is most likely an innovator or early adopter. "An enthusiastic 1st year teacher" is a clue in the teacher's *Personal Information* further supporting this assumption.

We have identified seven strategies that, in the context of the DSG, are expected to be effective in the game if it is consistent with the theory it is designed to teach (i.e., the DSG has theoretical content fidelity). These strategies are as follows:

1. Get to know the staff by reading *Personal Information*, using *Talk To*, and observing the interpersonal networks (via the network diagrams).
2. Take a client-oriented approach by avoiding *Confrontation* and *Compulsion*.
3. Utilize opinion leaders by selecting them for diffusion activities.
4. Provide opportunities for staff to evaluate the innovation by using *Pilot Test*, *Site Visit*, and *Demonstration*.
5. Select mass media communication channels to raise awareness of the staff by using *Local Mass Media* and *Print* early in the game.
6. Utilize interpersonal channels by selecting the highest networked staff members for diffusion activities.
7. Utilize early adopters by selecting them for diffusion activities.

Additional strategies could be deduced from the diffusion of innovations theory. We used our understanding of the theory to formulate the strategies most applicable to the context of the DSG.

Method

Participants and Data Collection

We generated the data analyzed in this study from the first 10,000 game sessions of the free version of the DSG played between 7 October, 2006 and 4 April, 2009. Although anybody with Internet access may have played the game, occasional email communications between users and the lead developer suggest that some of the players were university students learning about the diffusion of innovations theory and/or change management.

Data for each of the 10,000 sessions were stored in separate folders on the web server, each containing two XML files. One file contained summative information on the status of each game at the point in which the user stopped playing. This included the number of weeks elapsed, total adopters gained, total number of activities selected, and number of points for each adoption stage for each staff member. The other file contained information for each activity selected during the game. This included the diffusion activity selected along with any staff members selected for the activity, specific feedback obtained, and number of points awarded to individual staff members affected positively by the activity.

Data Preparation

Multiple steps were taken to prepare the data for analysis. First, we used a PHP script to migrate the XML files from the 10,000 folders into a MySQL database. To ensure data integrity, we checked the data for accuracy each time they were moved or manipulated.

Next, we agreed on criteria for selecting the records to use in the study. Of the 10,000 game sessions, almost half (4,489 games) ended with a player never selecting a single diffusion strategy. To look at strategies throughout the entire game, we chose to use only the records for games that had been fully completed. These finished games consisted of game sessions in which players completed all 72 weeks (ran out of time) or won the game by convincing all 22 staff members to adopt the innovation.

We used another PHP script to filter out all gameplay sessions that had not been completed and write only the data for finished games to a delimited text file. This script also parsed the staff members selected for the activity and stored them in separate fields to simplify data analysis. The final data set of finished games used in the study contained 2,361 game sessions consisting of 107,294 turns.

We imported the text file into a Microsoft Excel spreadsheet for analysis. To support data analysis, we created additional fields. One field identified each staff member's adopter type. Another field indicated whether a staff member was an opinion leader. We retrieved the specification of adopter types and opinion leaders from the original board game debriefing materials. We added other fields to indicate the final turn for each game session, to identify activities that required the selection of one or more staff members, to compile activity sequences and activity/staff combinations, and to aggregate other numeric fields.

To compare strategies used in the game, we divided the data set into three categories.

1. **Successful** strategies represented the 341 winning game sessions in which the player got all 22 staff members to adopt the innovation. Within these winning game sessions, some players needed up to 54 turns to obtain 22 adopters, whereas others needed as few as 18 turns.

2. **Unsuccessful** strategies represented the 1,532 games in which fewer than 16 staff members became adopters.
3. The **undetermined** strategies represented the remaining 488 games in which 16 to 21 adopters were gained.

Due to the variety of possible outcomes for each activity, these undetermined game sessions may have utilized successful or unsuccessful strategies. Given the stochastic nature of outcomes in the DSG, successful strategies may not always result in obtaining 22 adopters.

To determine the range in number of adopters for unsuccessful gameplays, we first looked for a naturally occurring break in the data which would indicate a separation between two groups. Figure 4 shows the distribution of scores for the game session studied. Notice the slight drop in the number of game sessions that finished with 15/16 adopters but this was not dramatic. Therefore we also relied on our own experience playing the game and observing others play the game in selecting scores from 0 to 15 as unsuccessful. Typically a player who uses mostly good strategies throughout the game will get a score of 16 or higher.

Analysis and Results

The summative information on each of the 2,361 games along with information for each of the 107,294 turns taken within games constituted a large set of data. To develop a general understanding of this amount of content, we used descriptive statistics (Table 1).

Answering the research questions required comparing the use of the identified strategies in successful and unsuccessful game sessions. Because an independent samples *t* test found a statistically significant difference between the mean number of turns for the two groups, $t_{.05}(1,871) = -36.00$, $p < .001$, frequencies of activity selection would not provide a meaningful metric. For instance, the number of times *Print* was used in successful game sessions could not be directly compared with the number of times it was used in unsuccessful game sessions because unsuccessful games typically had more turns. Instead, we calculated relative frequencies of activity selection for each game session and the means of these proportions for the successful and unsuccessful groups. These mean relative frequencies provided a common metric for comparison. In total, we did 53 independent samples *t* tests comparing successful and unsuccessful game sessions. To prevent inflation of the Type I error rate, each statistical test was considered significant only if $p < .001$, resulting in an overall Type I error rate of 0.0516.

Although inferential statistics are useful in facilitating comparisons of aggregated data, they may obscure important temporal and structural relationships (Frick, Howard, Barrett, Enfield, & Myers, 2009). Therefore, to analyze patterns of gameplay, Analysis of Patterns in Time (APT) was used (Frick, 1990). APT provides two ways of looking at patterns of gameplay within the DSG. First, sequences of activity selections can be analyzed. For

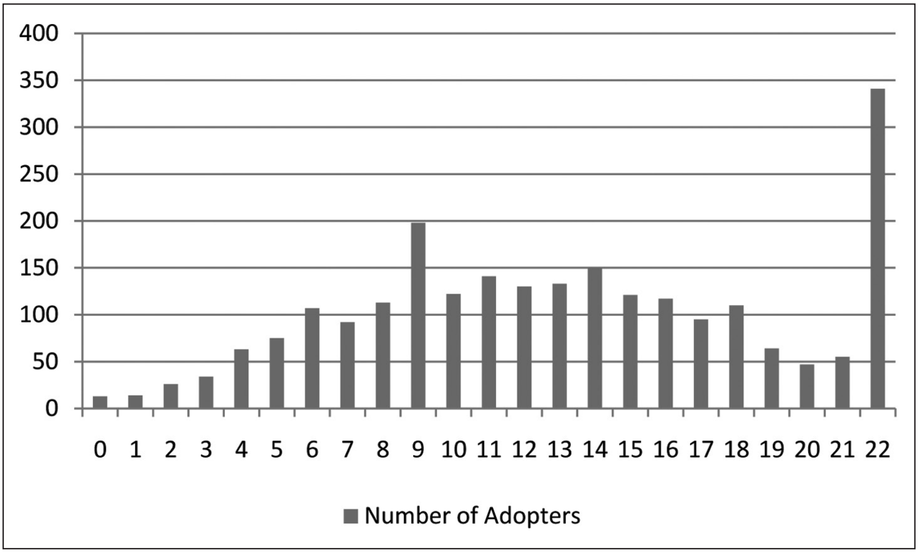

Figure 4. Frequency distribution of number of adopters in game sessions

Table 1. All Finished Games With Mean Number of Turns

Game type	Number of games	Number of turns	*M*	*SD*
Successful	341	11,276	33.07	5.791
Unsuccessful	1,532	73,941	48.26	7.299
Undetermined	488	22,077	45.24	6.728
Total	2,361	107,294	45.44	8.720

instance, the most common sequence of two successive activities selected in the game can be identified. Second, joint occurrences can be analyzed. For instance, the most common staff member selected for any given activity can be identified.

APT involves looking at patterns within a data set. With such a large data set, it would be neither reasonable nor desirable to analyze every possible pattern. Therefore, we adopted multiple strategies to select patterns to analyze. First, results of descriptive statistics gave insight into what common patterns existed within all finished games. Also, we calculated a frequency count for every sequence for combinations of two activities, three activities, and four activities. This allowed us to count the number of times a sequence of activities was used in all games and to compare usage between successful and unsuccessful games. Another approach was to examine patterns in individual games one at a time. Although this would not be practical to do for all game sessions, it was an effective way to look at patterns in distinctive games, such as games in which 22 adopters were gained in fewer than 26 turns. Most importantly, we relied on the diffusion of innovations theory to predict what patterns would lead to success. Once we identified patterns, we used techniques for filtering, counting, and querying to discover the frequency of those patterns within each game session.

Research Question 1: What strategies were successful in the game sessions being studied?

To answer this question, we compared the mean relative frequencies of the two groups' selections of activities using independent samples t tests. We found statistically significant differences for every activity ($p < .001$), except *Training Workshop (Self)*, $t_{.05}(1,871) = 1.74$, $p = .083$. Both groups used *Talk To* most frequently, with unsuccessful games selecting it more frequently ($M = 0.350$, $SD = 0.117$) than successful games ($M = 0.277$, $SD = 0.108$); the difference was statistically significant, $t_{.05}(1,871) = -10.51$, $p < .001$ with an effect size of .63 (Cohen's d). Throughout this report, we have calculated Cohen's d (a measure of differences in terms of standard deviation) using pooled variances. Cohen (1988) characterized $d = 0.20$ as a small effect size, $d = 0.50$ as a medium effect size, and $d = 0.80$ as a large effect size. In this case, the mean relative frequency of selecting *Talk To* by unsuccessful strategies is 0.63 standard deviations greater than that of successful strategies and is considered by Cohen to be a medium effect size.

The activities used more in successful sessions, arranged in decreasing order of effect size, were *Print*, *Site Visit, Local Mass Media, Materials Workshop*, and *Personal Information*. *Print* usage in successful games ($M = 0.172$, $SD = 0.134$) was 4.6 times greater than in unsuccessful games ($M = 0.038$, $SD = 0.032$), $t_{.05}(1,871) = 35.08$, $p < .001$; the effect size (Cohen's d) was 2.1. *Site Visit* usage in successful games ($M = 0.136$, $SD = 0.087$) was 2.8 times greater than in unsuccessful games ($M = 0.048$, $SD = 0.035$), $t_{.05}(1,871) = 30.05$, $p < .001$; the effect size (Cohen's d) was 1.8.

Because some activities are directed toward individual staff members, we analyzed the differences in staff member selection in the same manner in which we analyzed differences in activity selection. *Targeted activities* require selecting one staff member (*Ask Help*, *Demonstration*, *Pilot Test*, and *Talk To*) or up to five staff members (*Personal Information*, *Print*, and *Site Visit*). The mean relative frequency for the selection of targeted activities to all activities in unsuccessful games ($M = 0.776$, $SD = 0.090$) was not statistically significantly different than in successful games ($M = 0.765$, $SD = 0.076$). To compare the two groups' selection of staff members for each targeted activity, we divided the number of times each staff member was selected for each targeted activity by the total number of participants for that activity. We used the ratio of these numbers as the metric for calculating successful and unsuccessful group means for comparison.

Both groups chose A (Principal) most frequently for targeted activities, with unsuccessful games being slightly higher ($M = 0.106$, $SD = 0.045$) than successful games ($M = 0.081$, $SD = 0.037$); the difference was statistically significant, $t_{.05}(1,871) = -9.98$, $p < .001$, with an effect size (Cohen's d) of 0.60. The next four most frequently

Table 2. Most Frequently Selected Staff Members in All Targeted Activities

	Successful		Unsuccessful				
Staff member	*M*	*SD*	*M*	*SD*	*t*(1,871)	*p*	Cohen's *d*
A	0.08	0.037	0.11	0.045	−9.98	<.001	−0.60
E	0.07	0.023	0.04	0.026	17.95	<.001	1.07
K	0.06	0.016	0.03	0.020	26.69	<.001	1.60
T	0.06	0.019	0.03	0.021	25.19	<.001	1.51
R	0.05	0.018	0.02	0.018	27.98	<.001	1.68
F	0.05	0.048	0.06	0.038	−6.52	<.001	−0.39
M	0.04	0.030	0.06	0.036	−10.45	<.001	−0.63
D	0.05	0.015	0.06	0.030	−7.74	<.001	−0.46
G	0.04	0.020	0.06	0.031	−10.37	<.001	−0.62

selected staff members differed between the groups, with successful games choosing (in descending order) E (math teacher), K (social studies teacher), T (boys' physical education teacher), and R (art teacher). Unsuccessful games opted for F (math teacher), M (language arts chairman), D (math chairman), and G (science chairman). See Table 2 for details. It is worth noting that except for A (principal) the staff members most frequently chosen in successful games are all categorized as laggards in terms of Rogers's (2003) adopter types (E, K, T, and R). Although this may initially seem at odds with Rogers's theory, this may be explained by successful players' greater advancement in the game. By gaining most of the staff members as adopters earlier than the unsuccessful players, successful players may have had more time to target the last staff members to adopt (typically the laggards).

To further explore the differences in gameplay, we examined sequences in which activities occurred. For sequences of two activities, the most frequent pattern in both successful and unsuccessful games was *Talk To* followed by *Talk To* (*Talk To* → *Talk To*). However, the second most frequent pattern in successful games was *Print* → *Print*, whereas in unsuccessful games it was *Talk To* → *Ask Help*. For sequences of four activities, the most frequent pattern in successful games was *Print* → *Print* → *Print* → *Print*, whereas in unsuccessful games it was *Talk To* → *Talk To* → *Talk To* → *Talk To*.

It should be noted that the timing of *when* these strategies are used is important with respect to *stage of adoption* in diffusion of innovations theory. For example, although *Print* may be useful for raising awareness and interest early on, it would not be particularly helpful later on when an adopter is in the trial/appraisal stage of adoption. However, the extant data available to this study did not allow us to investigate these kinds of patterns. The adoption stage of the staff members selected for each activity was not saved.

We also examined the use of an activity with one or more staff members. As described above, successful games were more likely to utilize *Print* and *Site Visit*, both of which are activities that allow the selection of up to five staff members. For the

Table 3. Comparison of Strategies

Strategy	Successful		Unsuccessful			
Selections	*M*	*SD*	*M*	*SD*	*t*(1,871)	Cohen's *d*
Activity selection						
Print	0.172	0.134	0.038	0.032	35.08	2.1
Site Visit	0.136	0.087	0.048	0.035	30.05	1.8
Local Mass Media	0.095	0.074	0.047	0.051	14.40	0.9
Talk To	0.277	0.108	0.350	0.117	−10.51	–0.6
Ask Help	0.019	0.038	0.112	0.074	–22.60	−1.4
Staff selection						
Innovators	0.093	0.032	0.127	0.046	−12.86	–0.8
Early adopters	0.112	0.063	0.160	0.054	−14.55	–0.9
Early majority	0.199	0.045	0.194	0.068	6.24	0.4
Late majority	0.284	0.047	0.300	0.061	–4.55	–0.3
Laggards	0.247	0.051	0.127	0.055	36.99	2.2

Print activity, the most frequently selected staff members in successful games were A (principal), E (math teacher), K (social studies teacher), I (science teacher), and T (boys' physical education teacher). For *Site Visit*, the most frequently selected staff members in successful games were A (principal), K (social studies teacher), E (math teacher), R (art teacher), and T (boys' physical education teacher).

The successful strategies used in the game sessions studied are summarized in Tables 3, 4, 5, and 6.

> *Research Question 2:* Are the strategies that were successful within the game aligned with strategies that would be predicted by the diffusion of innovations theory?

The seven strategies (described earlier) we expected to be successful in the DSG were based on diffusion of innovations theory. We again compared the relative frequencies for the means of the two groups using independent samples *t* tests. The results for each strategy follow.

Strategy 1. Get to **know the staff** by reading personal information, talking to staff members, and observing the interpersonal networks. This strategy was comprised of one diffusion activity—*Talk To*—and all four information activities—*Personal Information*, *Lunchmates*, *Committees*, and *Social Groups Networks*. As a single construct, this strategy was employed more frequently in unsuccessful games ($M = 0.493$, $SD = 0.116$) than in successful games ($M = 0.401$, $SD = 0.118$), and the difference was statistically significant, $t_{.05}(1{,}871) = -13.22$, $p < .001$; the effect size (Cohen's d) was 0.79. Although this was unexpected, we do not know how many times a particular individual played the DSG. A player may have accessed the social network diagrams

Table 4. Most Frequent Joint Occurrences of Activities and Staff

Targeted activity Staff selection	Successful (% of total)	Unsuccessful (% of total)	Ratio
Talk To A	0.034	0.059	0.57
Site Visit K	0.032	0.006	5.00
Site Visit E	0.031	0.009	3.59
Print A	0.030	0.011	2.73
Site Visit R	0.027	0.004	6.02
Talk To B	0.016	0.024	0.66
Talk To C	0.014	0.018	0.76
Personal Information A	0.013	0.015	0.90
Personal Information B	0.013	0.015	0.90

Table 5. Joint Occurrence Patterns for Most Frequently Selected Targeted Activities

Targeted activity Staff selection	Successful (% of total)	Unsuccessful (% of total)	Ratio
Print	0.172	0.038	4.58
Principal	0.481	0.440	1.09
Opinion leaders	0.446	0.593	0.75
Networkers	0.745	0.822	0.91
Site Visit	0.136	0.048	2.81
Principal	0.041	0.380	0.11
Opinion leaders	0.215	0.671	0.32
Networkers	0.664	0.869	0.76
Talk To	0.277	0.350	0.79
Principal	0.262	0.232	1.13
Opinion leaders	0.126	0.150	0.84
Networkers	0.229	0.247	0.92
Ask Help	0.019	0.112	0.17
Principal	0.045	0.092	0.49
Opinion leaders	0.305	0.234	1.30
Networkers	0.301	0.355	0.85

in an earlier game, printed them for reference or remembered who was highly connected, and therefore did not need to select the diagrams at all in later games when he or she succeeded in getting all 22 adopters. In such cases, we may have underestimated values of this variable for successful gameplays.

Strategy 2. Take a **client-oriented approach** by avoiding *Confrontation* and *Compulsion*. This strategy entails the avoidance of two diffusion activities—*Confrontation*

Table 6. Comparison of Activity Sequence Patterns

Number of strategies Selections	Successful (% of total)	Unsuccessful (%of total)	Ratio
Two activity sequence			
Talk To → Talk To	0.141	0.164	0.86
Print → Print	0.107	0.003	36.22
Site Visit → Site Visit	0.058	0.003	21.99
Talk To → Ask Help	0.009	0.046	0.19
Ask Help → Talk To	0.005	0.031	0.18
Four activity sequence			
Print → Print → Print → Print	0.050	<0.001	175.18
Site Visit → Site Visit → Site Visit → Site Visit	0.016	<0.001	73.77
Personal Info → Personal Info → Personal Info → Personal Info	0.027	0.009	3.08
Talk To → Talk To → Talk To → Talk To	0.042	0.052	0.80
Personal Info → Talk To → Talk To → Talk To	0.007	0.011	0.60
Talk To → Personal Info → Talk To → Talk To	0.003	0.010	0.33

and *Compulsion*. As a single construct, these activities were used less frequently in successful games ($M = 0.001$, $SD = 0.007$) than in unsuccessful games ($M = 0.008$, $SD = 0.021$) as predicted. The difference was statistically significant, $t_{.05}(1,871) = -6.53$, $p < .001$; however, the effect size (Cohen's d) was only 0.39.

Strategy 3. Utilize **opinion leaders** by selecting them for diffusion activities. This strategy involves selecting one or more of the three opinion leaders—F (math teacher), H (science teacher), and M (language arts chairman)—for targeted activities. As described above in reference to the first research question, we calculated the relative frequency for the selection of these staff members in relation to the number of participants in targeted activities. Opinion leaders were used more frequently in unsuccessful games ($M = 0.178$, $SD = 0.058$) than in successful games ($M = 0.119$, $SD = 0.066$), and the difference was statistically significant, $t_{.05}(1,871) = -16.41$, $p < .001$; the effect size (Cohen's d) was 0.98. However, this must be interpreted with caution, as we neither know when opinion leaders became adopters during gameplay nor what stage of adoption they were when selected for an activity. An efficient strategy would be to get the opinion leaders to adopt as soon as possible to influence others. Once an opinion leader adopts, it would not make sense to involve him or her in activities such as *Print, Site Visit, or Mass Media.* On the other hand, she or he might be a good candidate for leading a *Demonstration* activity.

Strategy 4. Provide opportunities for staff to **evaluate** the innovation. This strategy is comprised of three diffusion activities—*Demonstration*, *Pilot Test*, and *Site Visit*. As a single construct, the mean relative frequency for successful games ($M = 0.182$, $SD = 0.088$) was not significantly different than for unsuccessful games ($M = 0.177$, *SD* = 0.068), $t_{.05}(1{,}871) = 1.12$, $p = .264$. It may be important to note that although *Site Visit* was preferred in successful games, *Demonstration* and *Pilot Test* were used more frequently in unsuccessful games. *Pilot Test* in particular was used more frequently in unsuccessful games (*M* = 0.077, *SD* = 0.025) than in successful games (*M* = 0.013, *SD* = 0.025), and the difference was statistically significant, $t_{.05}(1{,}871) = -22.79$, $p < .001$; the effect size (Cohen's *d*) was 1.36.

Strategy 5. Select **mass media** communication channels early in the game to raise awareness of the staff. This strategy is comprised of two diffusion activities—*Local Mass Media* and *Print*. To compare usage of these activities between the successful and unsuccessful game sessions early in the game, we analyzed only the first 15 turns. The two activities were heavily favored in successful games. As a single construct, this strategy was over 5 times more likely to be used in successful games (*M* = 0.365, *SD* = 0.207) than in unsuccessful games (*M* = 0.065, *SD* = 0.092) during the first 15 turns, and the difference was statistically significant, $t_{.05}(1{,}871) = 41.33$, $p < .001$; the effect size (Cohen's *d*) was 2.47.

Strategy 6. Utilize **interpersonal channels** by selecting the highest networked staff members for diffusion activities. We used methods from social network analysis (Scott, 2000) to determine highly networked staff members. We combined the three diagrams (*Committees*, *Lunchmates*, and *Social Groups*) into a single, undirected graph with each staff member as a vertex and each connection to another staff member as an edge. To keep things simple, if multiple edges existed between two vertices (e.g., A and D were connected on both the *Committees* and *Lunchmates* diagrams), we treated them as a single, unweighted edge. The number of edges a particular vertex has is referred to as its degree (Newman, 2003). We examined the degree distribution of the graph to determine which vertices had the highest degrees, and we chose the top 25%. These staff members had 10 or more connections to other staff members; they included F (math teacher), G (science chairman), H (science teacher), J (social studies chairwoman), L (social studies teacher), V (home economics teacher), and W (guidance counselor).

We used the process described above for calculating the selection of staff members (in reference to the first research question) to calculate the relative frequency for highly networked staff members. Highly networked staff members were used more frequently in unsuccessful games (*M* = 0.322, *SD* = 0.063) than in successful games (*M* = 0.252, *SD* = 0.049), and the difference was statistically significant, $t_{.05}(1{,}871) = -18.93$, $p < .001$; the effect size (Cohen's *d*) was 1.13. This finding is puzzling and unexpected. Further research is needed to investigate other properties of network component connectivity such as flexibility (i.e., number of alternate pathways from a given node to each other node, both direct and indirect) or compactness (average distance between a node and other nodes connected to that node).

It should be further noted that weighting these network connections equally may not be justifiable. For example, it may matter less how many people one knows, compared with *who* one knows—with respect to social influence. Those staff members in the DSG who are connected socially to the principal and who are opinion leaders or the early majority may help move the principal to adoption more effectively than other staff who are less well connected. Strategically, if the principal becomes an adopter early in the DSG, then diffusion activities with other staff are often more effective under this condition (e.g., for *Site Visit*).

Strategy 7. Utilize **early adopters** by selecting them for diffusion activities. The early adopters are F (math teacher), M (language arts chairman), and X (library/AV coordinator). We used the process described above (in reference to the third strategy) for calculating the selection of opinion leaders to calculate the relative frequency for early adopters. Early adopters were used more frequently in unsuccessful games (M = 0.160, SD = 0.054) than in successful games (M = 0.112, SD = 0.063), and the difference was statistically significant, $t_{.05}(1,871) = -14.55, p < .001$; the effect size (Cohen's d) was 0.87.

In summary, the analysis suggests that three of the strategies predicted to be effective by the theory were aligned to successful game strategies. They were

- Strategy 2: Take a **client-oriented approach** by avoiding *Confrontation* and *Compulsion*.
- Strategy 4: Provide opportunities for staff to **evaluate** the innovation.
- Strategy 5: 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 did not appear to be aligned to successful game strategies. They were

- Strategy 1: Get to **know the staff** by reading *Personal Information*, using *Talk To*, and observing the interpersonal networks (via the network diagrams).
- Strategy 3: Utilize **opinion leaders** by selecting them for diffusion activities.
- Strategy 6: Utilize **interpersonal channels** by selecting the highest networked staff members for diffusion activities.
- Strategy 7: Utilize **early adopters** by selecting them for diffusion activities.

However, these findings may be misleading. Due to insufficient data, discussed later as a limitation of the study, these findings should be considered very cautiously.

Research Question 3: Do other successful strategies exist that do not relate to theories of the diffusion of innovations?

To answer this question, we examined successful games that were completed in fewer than 26 turns. Coincidentally, 26 games were completed in fewer than 26 turns. We chose these games, referred to as *extreme winners*, because they obtained all 22 adopters more quickly than in other successful games. The average number of turns in these games was 22.92, with the fewest being 18. As mentioned earlier in

Table 1, successful games, which include the extreme winners, had a mean of 33.07 turns. In games with extreme winners, the most frequently selected activity was *Site Visit*, which was used an average of 5.19 times per game and constituted 22.65% of all turns. The second most frequently selected activity, *Talk To*, was used an average of 5.04 times per game, which constituted 21.98% of all turns. The third, *Local Mass Media*, was used an average of 4.15 times per game and constituted 18.12% of all turns. The fourth, *Print*, was used an average of 3.92 times per game and constituted 17.11% of all turns. The game in which only 18 turns were needed to obtain 22 adopters was the only extreme winner to utilize *Confrontation*, which was used twice. It should be noted that the likelihood of *Confrontation* working successfully twice in one gameplay is very rare—according to decision algorithms in the DSG software. Hence, this extreme winner was very lucky.

Within games with extreme winners, the three most common sequences of four activities were (a) *Print → Print → Print →Print*, (b) *Site Visit → Site Visit → Site Visit → Site Visit*, and (c) *Mass Media → Mass Media → Mass Media → Mass Media*. The most common combinations of targeted activities and staff members were *Print* with A (principal), *Site Visit* with D (math chairman), *Talk To* with A (principal), and *Site Visit* with E (math teacher).

Discussion

The present study assessed the fidelity of the underlying computational model with respect to the conceptual model that it represents. The discrepancies between the strategies that were predicted to be successful based on the conceptual model and the successful strategies in the findings suggest flaws in the underlying computational model of the DSG. However, in interpreting these discrepancies, we must keep in mind alternative explanations. For Strategy 1, for example, the fact that successful game sessions used *Personal Information* and interpersonal network diagrams less frequently may be due to the players' familiarity with that information from previous game sessions. For Strategies 3, 6, and 7, the underutilization of opinion leaders, highly networked staff, and early adopters may be because other strategies (e.g., using *Site Visit* and *Local Mass Media*) are overly successful. Although the findings indicate the need to adjust the game's algorithms so that outcomes are more consistent with Rogers's (2003) theory, the designers must use their judgment followed by further testing to determine the correct balance of actions and results.

A follow-up study in progress addresses the limitations of the current study by using a computer program to "replay" the game sessions and collect the missing data. The follow-up study will provide a more nuanced analysis of gameplay patterns and provide the foundation for guidelines that simulation developers can follow to define, collect, and analyze interaction data for model verification.

Two recently conducted studies assessed the effectiveness of the DSG with additional instructional support. Lara, Enfield, and Myers (in press) assessed the learning gains of learners who played the game once, were provided with information about the core concepts of the diffusion of innovations theory, and then played the game two additional times. Kwon, Lara, and Enfield (2010) compared the game performance, learning gains, and perceptions of learners who played the DSG one time with instructional support. In this study, participants were provided with optional or forced prompts throughout the game that included information about the theory and strategies that should be effective in diffusing the innovation. Both of these studies included qualitative methods with a small number of participants and revealed a concern for novice players experiencing cognitive overload due to the amount of information and complexity of the DSG. Also, both studies used a minimal approach to instructional support which, according to Kirschner, Sweller, and Clark (2006), is not very effective. Though much was learned from these studies, the interventions did not yield large learning gains.

Another study being conducted with the DSG involves an instructional strategy that comprises more than minimal instructional support. This instructional support is embedded in the DSG as training for new players. This instructional support is currently being designed and developed and follows Van Merriënboer's 4C/ID model (Van Merriënboer, Kirschner, & Kester, 2007) for complex learning. Using this instructional design model should help reduce cognitive load and allow players to gradually develop an understanding of the diffusion of innovations theory.

It is important to note that records in the extant DSG data set did not permit us to answer questions about patterns relevant to diffusion of innovations in as much detail as we wanted. According to diffusion of innovations theory, it should matter *when* a particular diffusion strategy is used, with respect to the adoption phase of an individual. For example, use of mass media would be expected to be helpful in early stages of adoption (raising awareness and interest) but not particularly helpful when one is in the trial/appraisal stage of adoption. For the latter, strategies relevant to the decision phase (trial/appraisal in DSG) would be applicable, such as *Site Visit* or observing a *Demonstration* by a peer adopter. However, the extant data set did not allow such detailed analysis.

Moreover, relative frequencies of diffusion activities may not be the best metric for comparing DSG results with Rogers's (2003) diffusion of innovations theory. For instance, using the *Print* activity at the appropriate time with the appropriate staff members may be much more effective than using it frequently. Unfortunately, strategies that involved targeting individuals at a specific adoption stage could not be considered with the available data. The implication of this is clear for revision of the record keeping system for the DSG to support a more in-depth analysis using APT. Had the adoption stage for each staff member been stored along with the selection of each activity, we would be able to more confidently answer our research questions here.

Second, the algorithms for the DSG were created in 1976, based on what was known about the diffusion of innovations and change management at that time. Although Rogers's (2003) theory was initially proposed in the early 1960s, it has undergone modification over four decades. For example, Rogers changed some of his terminology in later editions of his book, and additional empirical evidence was considered.

When speaking with one of the original developers (Michael Molenda), he indicated that the DSG algorithms were based not only on Rogers's (2003) theory but also on other relevant empirical evidence. One of the surprising outcomes of the present study, as discussed earlier, was the greater proportion of activities spent with laggards in the successful games compared with unsuccessful ones.

So which is right? The DSG algorithms or Rogers's (2003) theory? The DSG algorithms do form an implicit decision flowchart that a change agent might follow, so it could be transformed into a set of conditional strategies for action—that is, a prescriptive theory. If the DSG model predicts accurately what was unexpected according to Rogers's theory, then the DSG model would be a stronger alternative theory—assuming that the DSG also correctly predicts other expected situations as does the diffusion of innovations theory. This could lead to an interesting research study to see whether the unexpected prediction from the DSG prescriptive theory is empirically supported. If so, then the apparent inconsistency between our findings and Rogers's theory is actually a desirable outcome.

In summary, we should remain cautious about conclusions from the present study. The present findings serve as a springboard for further research. APT had not been used as a method of investigating simulations and games for learning. The attempt to use APT in this study clearly pointed out the need for storing detailed temporal maps of gameplay to do the kinds of pattern analyses that we would have wanted to do.

Debriefing With the DSG

Even when the fidelity of a simulation is high, user experiences may vary greatly due to the interactive nature of the simulation. Debriefing allows learners to corroborate whether their assumptions made by interacting with the simulation were correct and clarifies the learning objectives of the simulation (Peters & Vissers, 2004). The use of debriefing with the DSG may be effective in reconciling misconceptions, if any, developed from players' experiences.

When the DSG is used in an instructional context such as a college classroom or corporate workshop, instructors are provided with a two-page discussion guide to debrief participants following DSG play. This debriefing is intended to help players see the connections between types of adopters according to Rogers's (2003) theory and rules of thumb for successful diffusion strategies modeled in the DSG. As the DSG has been played over three decades as a board game and over 6 years online in instructional contexts where debriefing has been included, debriefing was not of concern in this particular study. Rather, we focused on the winning strategies discovered by players and fidelity of these strategies with Rogers's theory. Moreover, debriefing materials are not included as part of the free version of the DSG (studied here) as they are with the full, licensed version.

Limitations of the Study

The most restraining limitations of this study resulted from how the data were collected. The data collection was not designed to support analysis but to preserve game state. Hence, much of the data that would have been useful in answering the research questions was unavailable. As previously discussed, the adoption stage of individuals selected for activities is unknown. Also, for any given turn, it is unknown which staff members have adopted the innovation. Not knowing which staff members were adopters made it impossible to look at whether players were targeting individuals who had already adopted the innovation for diffusion activities. It would have been of particular interest to know when the principal had become an adopter based on the rules underlying the DSG; some of the outcomes for selecting an activity have more impact once the principal has adopted the innovation.

Possibly the most important piece of missing data was player identification. Without a player identifier, successive or repetitive gameplays could not be studied. No procedure existed for the researchers to determine whether a given game session was the result of a 1st attempt at gameplay or the 100th. This also meant that gameplay patterns for individuals could not be determined. Without this information, it was impossible to see whether and how quickly players' strategies improved or what strategies attempted lead to the discovery of successful strategies. In short, it was impossible to see how players' behaviors changed from one game to another.

Another limitation of the study relates to the arguable classification of the *Print* activity as a mass medium channel of communication. This activity involves giving a brochure to five staff members. On one hand, *Print* does not strictly fit Rogers's (2003) definition for mass media communication because it is targeted at particular staff members instead of being available to all staff members on a voluntary basis. On the other hand, it is a print brochure which is a medium that is typically used for mass distribution. Also, because the activity targets five people through a printed brochure, it would be hard to classify the activity in Rogers's alternative category of interpersonal communication channels. A possible resolution to this argument in future research may be in changing the activity in the DSG so that it is sent to all staff members as would be expected with a brochure.

Implications for Future Research

Although some findings resulted from insufficient data, they still raise concerns about what players may be learning and suggest a need for additional research to assess what learning, if any, occurs from playing the DSG.

Given the large amount of literature that suggests that debriefing should be used to support learning with games and simulations, future research may address questions of how to best use debriefing with the DSG. For instance, because the game is used in some distance courses, research on how to best facilitate debriefing online may be useful.

Also the limitations of the study point to a need for designing a data collection method with analysis of patterns of gameplay in mind. This study has already informed the design of the data collection for the newest version of the DSG recently developed. For other simulations and games as well, data should be collected at a very granular level to analyze gameplay patterns. Especially if players' successive gameplays can be analyzed, the patterns would be one indication of learning, or lack thereof. With partial data, as was available for this study, APT was useful but could have revealed much more had the appropriate data been collected. The use of APT made a more rigorous evaluation of strategies possible and should be considered as a potential method for analyzing gameplay by other researchers.

Overall Significance of the Study

Currently, a new Flash-based version of the DSG is almost complete. Besides an improved user interface, this version of the DSG includes an improved data collection backend to support more rigorous gameplay analysis. The data will include the player and game-session ID so that performance over multiple game sessions may be examined. The data will also include the adoption stage of each staff member being targeted. This will allow researchers to examine the appropriateness of staff member selection for particular activities based on their current adoption stage in the game.

In addition to informing the redesign of the DSG's record keeping system, this study illustrates analysis of gameplay through objective, rigorous methods that contrast with the anecdotal observations that are typical of many studies that involve games and simulations for learning.

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Bios

Jacob Enfield is a game researcher interested in the potential of games for promoting learning. He has completed a BS in secondary education, an MS in educational technology, and is currently a doctoral candidate in instructional systems technology (IST) at Indiana University (IU). He also designs and develops educational and entertainment games. A portfolio of his creative work is available at http://www.seriousgamegroup.com/portfolio.

Rodney D. Myers is a doctoral candidate in IST at IU. His research interests include the design and use of games and simulations for learning. From a design perspective, he studies how instructional games/simulations are conceived, created, and improved. From a learning perspective, he explores methods for evaluating the effectiveness of games/simulations in promoting learning.

Miguel Lara is a doctoral candidate in IST at IU, Bloomington and focuses on the design and development of online learning environments and collaborative game-based learning.

Theodore W. Frick is a professor at IU. His research has focused on improving teaching and learning quality, including computer-based simulations and games for learning. He is further interested in empirical methods of pattern analysis to provide insight into relationships between instructional methods and learning outcomes. His theoretical work focuses on epistemology and measurement of learning, including algorithms for computer-adaptive testing.