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Communication Technology, Student Learning, and Diffusion of Innovation

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Abstract

Rogers' diffusion of innovation model was used to examine the adoption and contribution of a web-based course management system at a college campus. This study surveyed 196 students. It was found that Rogers' model successfully explained the adoption of the innovation. The adoption of the innovation also led to increased interaction between students, instructors, and course materials. The increased amount of interaction, in turn, significantly contributed to student learning. A path model was developed to examine the direct and indirect effects among variables. Contextual factors, such as student motivation, student learning styles, and computer skills, were examined.

Diffusion of innovation as a mass communication theory has been used to examine how an innovation is adopted in a particular social system. Since the pioneer of diffusion study, Ryan and Gross' study on the adoption of hybrid seed corn (1943), the diffusion of innovation model has been used to examine the diffusion of new products, ideas, and practices around the world. Diffusion of innovation, with its practical implication on the adoption of technological innovations, can be used as a theoretical framework to understand how students adopt a web-based course management system and integrate this system into their learning environment.

The Iowa study of the adoption of hybrid seed corn by Iowa farmers revealed how social change could be examined via the analysis of the adoption of innovation. The Iowa study researched the overall pattern of adoption by focusing on background factors that contribute to the adoption of the new seeds, the role of the mass media and interpersonal communication in the adoption process, and the time lag between awareness and adoption (Ryan & Gross, 1943). It is found that while the mass media contributed to the awareness of the innovation, interpersonal communication among farmers was the determining factor for the adoption of the new seeds.

Another landmark in the diffusion study is Rogers' model of diffusion of innovation (Rogers, 1995). In this model, Rogers specified four elements in the diffusion process: the innovation, communication channels, time, and the social system. With regard to the innovation, Rogers identified the five characteristics of an innovation: relative advantage, compatibility, complexity, trialability, and observability. An innovation has to be relatively advantageous, compatible with the existing values or needs of potential adopters, and simple to use. An innovation that can be experimented with on a limited basis and is visible to others will also be more likely to be adopted.

The mass media and interpersonal communication play a different role in the diffusion process. Consistent with what the Iowa study found, Rogers (1995) stated that the mass media are more effective in informing individuals about the innovation, but an individual's interpersonal contacts determine whether the individual will adopt the innovation or not.

Individuals adopt innovations at different rates depending on the innovativeness of the individual and the social context. Rogers (1995) noted three types of innovation decisions: optional, collective, and authoritative. Optional decisions pertain to when an individual can make adoption decisions independent of the other members in a social system. Collective decisions are made by consensus among members of a social system, while authoritative innovation decisions are made by a few members in a social system who have the power, status, or expertise. The rate of adoption is fastest when authoritative decisions are made, followed by optional decisions, and then collective decisions.

Rogers (1995) states that no other field of behavior science research has generated "more effort by more scholars in more disciplines in more nations" (p. xv.). Diffusion research has been conducted in a variety of fields ranging from medical, agricultural, business, educational, national development, and communication technology. I will review diffusion research conducted in the fields of education and communication technology to lay a foundation for the examination of the diffusion of a web-based course management system on a college campus.

Studies have shown the benefits of web-based technologies in enhancing student learning. For example, communication technologies supported learning by providing course information, study material, and assignments conveniently, timely, and in usable formats (Parikh & Verma, 2002; Silva, 2003; Riffell & Sibley, 2003). Web-based communication technologies made interaction between student with course material, faculty, and other students possible and facilitated students' critical thinking and writing skills (Meyer, 2003). Web-based communication technologies also made active learning feasible where students could design their own course content and post the course content on the web, in contrast to the traditional learning method where the instructor was the main source of course information (Lim et. al., 2003; Stocks & Freddolino, 2000).

Given that a web-based course management system is a computer-related innovation, previous research in this direction is helpful in understanding the diffusion of this education technology. In assessing the diffusion of on-line research in newsrooms, Garrison (2000) found that journalists had increasingly relied on the web for information gathering and e-mail. Herling (1996) found three factors that explained the resistance to the adoption of Lexis/Nexis, an on-line news database. The first factor was functional benefits factor, which explained nonadoption from the perspectives of necessity and benefits of the innovation. When an individual perceived little necessity and few benefits in adopting the innovation, resistance occurred. The second factor was innovation amenability factor, which examined how willing an individual was to change to allow adoption to occur. If an innovation required some adjustments in an individual's routine, and the individual was not willing to make the adjustment, adoption was less likely to occur. The third factor was innovation adaptability, which examined the need for the innovation to adapt to the individual. Although Herling (1996) conducted his study to address the pro-innovation bias in Rogers' model by assessing nonadoption, the results showed that relative advantage, compatibility, complexity, and trialability from Rogers' model were relevant to explain the nonadoption process.

The social context within which diffusion takes place was assessed in a few recent studies. In investigating the organizational-level decisions to adopt Internet websites, Flanagin (2000) found that organizational features, perceived benefits of innovations, and social pressures were significant predictors of an organization's website adoption. Moreover, social pressures at the interorganizational level was critical in discriminating adopters from nonadopters. Mahler and Rogers (1999) investigated the adoption of telecommunications technologies by 392 German banks and found that the primary reason for not adopting the innovations was perceived low rate of diffusion. In other words, an organization would be less likely to adopt an innovation when it perceived that not many other organizations had adopted the innovation. Burt (1987) examined the role of social contagion in medical diffusion and found that the social contagion that functioned through structural equivalence successfully predicted the adoption of a new drug. In other words, a physician's adoption was strongly predicted by the behavior of his peers in the same medical hierarchy (the structural equivalence) and was unaffected by the behavior of other people with whom he discussed cases.

The preceding literature suggests the following hypotheses concerning the adoption a web-based course management system by college students:

H1: Based on Rogers' model, advantageous innovation characteristics, such as relative advantage, complexity, trialability, and compatibility, will predict the adoption of a web-based course management system by college students. The four factors will also contribute the interaction between instructors, students, and course materials. The four factors will contribute to student learning. Observability does not apply here so it will not be tested.

H2: Meyer (2003) called for the examination of how individual student differences in terms of learning style, motivation to learn, computer skills, and ability to self-regulate affect the use of communication technologies. The second hypothesis of this study examines how student characteristics affect the adoption of this course management system. Three variables will be assessed: student motivation, student learning styles, and instructors' requirement.

H2a: Students who are more motivated tend to use the technology more.

H2b: This course management system benefits aural, dependent, and visual learners equally well.

H2c: The frequency of the use of this technology is predicted by instructors requiring participants to do so.

H3: Previous research (Beveridge and Rudell, 1988) indicated that the assessment of the use of a particular technology should take technological knowledge and attentiveness into consideration. As a result, it is hypothesized that computer skills, whether participants were informed about and interested in technological inventions, and whether participants initiated technological discussions moderately correlate with the use of the communication technology. The hypothesized moderate effect is because the course management system under study is a user-friendly software hence does not require much technological expertise to use it.

H4: The use of the course management system contributes to the interaction between students, instructors, and course materials.

H5: The increased interaction contributes to student learning.

Method

Participants

Participants in this study were 196 undergraduate and graduate communication students at a college in Western New York. The survey was administered to students enrolled in communication courses in Spring 2004. 54% of the students surveyed were females, 36% were males, and 11% were unknown. 18% of the participants were 18 or 19 years old, 51% were between 20 to 22 years old, 11% were between 25 to 30 years old, 10% were between 23 to 25 years old, and 4% were over 30 years of age. In terms of year in school, 8% were freshmen, 24% sophomores, 28% juniors, 26% seniors, 4% graduate students, and 11% unknown. The majority of the participants (66%) did not have prior experience with a web-based course management system, while 26% did have prior experience with a similar system.

Procedure

Student were told before the questionnaires were distributed that they would be asked questions concerning their experience with ANGEL, the web-based course management system used by the College where the survey took place. All of the questionnaires were completed in class.

Measures

The survey asked questions based on Rogers' model of the characteristics of innovation: relative advantages, compatibility, complexity, and trialability. Observability does not pertain to the use of a web-based learning system so it was not included in the study. Learning related questions, interaction questions, and technology related questions were asked to assess the impact and the context of the adoption of a web-based learning system by students. All of the questions were answered on 5-point Likert scales. A list of questions pertaining to each variable examined in this study is in Table 1, mean scores and standard deviations are included.

Table 1: **Measures**

Independent Variables		M	SD
Relative Advantage		M	SD
A1:	"ANGEL contributes to the quality of teaching."	2.51	.88
A2:	"Using ANGEL saves time."	2.47	.93
A3:	"ANGEL is a positive innovation."	2.96	.73
A4:	"ANGEL makes it more convenient to communicate with my professors."	2.83	1.01
Compatibility		M	SD
P1:	"ANGEL is compatible with the way I like to work."	2.54	.94
P2:	"Using ANGEL would require me to change my work habits."	2.48	1.00
P3:	"ANGEL is compatible with the computer system I use at home/in my dorm room."	1.81	.90
Simplicity		M	SD
X1:	"ANGEL is easy to use."	3.22	.72
X2:	"I am confident in my ability to use ANGEL."	3.46	.60
X3:	"ANGEL is too complex for me."	3.43	.72
X4:	"ANGEL is user-friendly."	3.07	.78
Trialability		M	SD
T1:	"I can practice using ANGEL at a comfortable pace."	2.73	.82
T2:	"ANGEL can be easily tried out."	2.86	.81
T3:	"I am not worried about making mistakes, i.e. clicking on the wrong item, when I use ANGEL."	2.92	1.06
Motivation		M	SD
M1:	"I hand in my assignment on time most of the	3.45	.81

	time."		
M2:	"I do not miss classes without a good reason."	2.53	1.29
M3:	"I am a self-motivated learner."	2.64	.95
Learning Style		M	SD
Y1:	"I can comprehend course material better after I listen to the instructor's lecture."	3.40	.83
Y2:	"I rely on the instructor's guidance in mastering the course material."	2.72	.94
Y3:	"I learn better with step-by-step demonstration."	2.55	.95
Instructor's Requirement		M	SD
R1:	"I use ANGEL because my professors post course materials on ANGEL."	3.34	.84
R2:	"I use ANGEL because my professors require me to do so."	2.90	.96
Informed about technology		M	SD
F1:	"How informed do you think you are about new scientific discoveries?"	2.75	.96
F2:	"How informed do you think you are about the use of new technological inventions?"	2.71	.89
F3:	"How often do you use the media for information on new technological inventions?"	2.07	.94
F4:	"How often do you use the Internet to gain information on new technological inventions?"	2.04	1.04
Interest in technology		M	SD
N1:	"How interested are you in new scientific discoveries?"	2.43	.95
N2:	"How interested are you in the use of new inventions and technologies?"	2.44	.88
Computer Skills		M	SD
S1:	"I am pretty good with the computer."	3.17	.79
S2:	"I am knowledgeable about computer hardware."	2.59	1.01
S3:	"I am knowledgeable about computer software."	2.75	.89
Initiate discussion on technology		M	SD
D1:	"How often do you initiate a discussion on new technological inventions?"	3.49	1.12
	Dependent Variables		
Frequency of Usage		M	SD
F1:	"How often do you use ANGEL?"	2.98	1.02
Interaction		M	SD
C1:	"ANGEL increases my interaction with my instructors."	2.31	1.02
C2:	"ANGEL increases my interaction with course material."	2.50	.96
C3:	"ANGEL increases my interaction with my fellow students."	1.82	1.12
Learning		M	SD
L1:	"I believe I learn the course material better	1.71	.98

	because of ANGEL."		
L2:	"Using ANGEL improves my grade."	1.86	1.01

Note: All questions were coded on 5-point Likert scales with 5 coded as "Strongly agree" and 1 as "Strongly disagree."

Relative Advantage. According to Rogers (1995), relative advantage is the degree to which an innovation is perceived as better than the option it supersedes. Important factors include economic advantage, social prestige, convenience, and satisfaction. An innovation perceived to be advantageous would have more rapid rate of adoption. The advantages of using this web-based learning system were measured by asking participants how the technology benefited them in their learning. Participants were asked whether they "strongly agree," "agree," "neutral," "disagree," or "strongly disagree" with the following statements: "ANGEL contributes to the quality of teaching," "Using ANGEL saves time," "ANGEL is a positive innovation," and "ANGEL makes it more convenient to communicate with my professors."

Compatibility. Compatibility is the degree to which an innovation is perceived as being consistent with the existing values, past experiences and practices, and needs of adopters (Rogers, 1995). This second component of Rogers' model was assessed by whether the adoption of the course management system would require the participants to change their work habits and whether the course management system was compatible with their computer system at home or in their dorm room.

Simplicity. According to Rogers (1995), complexity is the degree to which an innovation is perceived as difficult to understand and use. Innovation that is easy to use will more likely to be adopted and will be adopted faster. The term "complexity" in Rogers' model actually pertains to whether it is simple to use the innovation. As a result, simplicity will be measured in this study. Items included, "ANGEL is easy to use," "ANGEL is user-friendly," "ANGEL is too complex for me," and "I am confident in my ability to use ANGEL."

Trialability. Trialability pertains to the degree to which an innovation may be experimented with on a limited basis (Rogers, 1995). Trialability was assessed by the degree to which the course management system could be easily tried out by participants. Items included, "I can practice using ANGEL at a comfortable pace," "ANGEL can be easily tried out," and "I am not worried about making mistakes, i.e. clicking on the wrong item, when I use ANGEL."

There are three learning related variables investigated in this study: student motivation, student learning style, and adoption out of requirement from the instructors.

Student motivation. Whether participants were motivated learners was assessed by questions pertaining to whether they handed in their assignment on time, kept good attendance, and whether they thought they were self-motivated learners.

Learning style. Three learning styles were investigated: visual, aural, and dependent, to examine how the communication technology benefited different types of learners. Items included, respectively, "I learn better with step-by-step demonstration," "I can comprehend course material better after I listen to the instructor's lecture," and "I rely on the instructor's guidance in mastering the course material."

Instructors' requirement. The frequency of the use of the communication technology was also hypothesized to be affected by whether the instructors required students to go on-line to get assignments, take quizzes, or submit homework. Questions that assessed the reasons for the use of the technology were asked, "I use ANGEL because my professors post course materials on ANGEL," and "I use ANGEL because my professors require me to do so."

Four technology related questions were also administered. The four variables examined were: computer skills, informed about technology, interested in technology, and whether participants initiated discussion on technology.

Computer skills. In order to assess whether students who were less competent on the use of computer hardware and software would benefit less from the technology, self-report questions on computer skills were included, "I am pretty good with the computer," "I am knowledgeable about computer hardware," and "I am knowledgeable about computer software."

Informed about technology. To assess whether participants were informed about technology, participants were asked whether they thought they were informed about new scientific discoveries, and the use of new technological inventions. Questions on participants' information seeking behaviors regarding new technological inventions were also included.

Interest in technology. To investigate whether participants' interest in technology would affect the adoption and the use of the learning technology, questions on whether participants were interested in new scientific discoveries and in the use of new inventions and technologies were administered.

Technological discussion initiation. One question was administered to assess this variable: "How often do you initiate a discussion on new technological inventions?" This question was answered on 5-point Likert scales.

The three dependent variables were measured as follows:

Adoption of the innovation. The adoption of ANGEL was measured by asking students how often they use ANGEL. Do they use ANGEL "a few times a day," "a few times a week," "once a week," "once in a while," or "rarely"?

Interaction. Interaction between students, instructors, and course materials was measured by asking participants whether they "strongly agree," "agree," "neutral," "disagree," or "strongly disagree" with the following statements: "ANGEL increases my interaction with my instructors," "ANGEL increases my interaction with course material," and "ANGEL increases my interaction with my fellow students."

Learning. Learning was assessed by asking participants whether they learned the course material better because of the technology and whether they believed that the course management system improved their grade.

Explanatory Factor Analysis

Two explanatory factor analyses were conducted to assess the reliability and validity of this investigation. For the first factor analysis, all innovation variables and learning related variables were entered with Direct Oblimin rotation. Results are shown in Table 2. This factor analysis indicates that among the four components in Rogers' model, relative advantage and compatibility emerged as one factor. In addition, two of the three compatibility measures (P1 and P3 in Table 1) did not cluster with the rest of the relative advantage measures and were dropped, the one compatibility measure that clustered with the advantage measures (P2) was moved to the advantage factor. Visual learning style (Y3 in Table 1) did not cluster with the rest of the learning style variables and was dropped. The rest of the two learning style measures were labeled as dependent learning styles in future analysis because both questions pertain to the dependence the participants had on the instructors to learn the materials.

Table 2: **Factor Analysis of Innovation Predictors and Learning Related Predictors**

Variable						
	Factor Loading					
	1	2	3	4	5	6
Trialability						
T1	.824	.049	.110	-.172	-.096	.332
T2	.790	.040	.119	-.345	.052	.412
T3	.484	-.016	-.044	-.324	.073	.363
Instructor Requirement						
R1	.097	.810	-.028	-.245	.071	.174
R2	-.036	.796	.021	.033	.299	-.064
Motivation						
M1	.168	.213	.766	.058	-.047	.145

M2	.113	-.060	.716	-.089	.217	-.019
M3	-.176	-.207	.679	-.290	-.079	.172
Relative Advantage/Compatibility						
A1	.151	.023	.050	-.786	.131	.242
A2	.040	.063	.021	-.766	-.077	.351
A3	.493	.108	.131	-.733	-.067	.396
A4	.292	.312	.068	-.710	.001	.370
P1	.420	.016	.267	-.678	-.128	.305
Dependent Learning Style						
Y1	.003	.109	.038	.033	.810	.003
Y2	.023	.223	.057	-.033	.763	-.053
Simplicity						
X1	.420	.110	.241	-.358	-.090	.807
X2	.362	-.012	.161	-.341	.024	.787
X3	.136	.038	-.090	-.241	-.031	.770
X4	.473	.135	.215	-.328	-.096	.750
Total Variance Explained: 63.1%						

The second factor analysis pertains to the technology related variables. Three factors emerged from the data: informed, computer skills, and interest. Discussion variable clustered with all the informed about technology variables and was moved to the informed factor. Results of this factor analysis are shown in Table 3.

Table 3: **Factor Analysis of Technology Related Predictors**

Variable.			
	Factor Loading		
	1	2	3
Informed about technology			
F2	.851	.090	.185
F4	.791	-.105	.068
F1	.753	.141	.339
D1	.722	-.006	.002
F3	.647	-.070	.303
Computer skills			
S3	-.002	.898	-.007
S2	-.021	.874	-.063
S1	.018	.843	-.055
Interest in technology			
N2	.166	-.114	.905

N1	.214	.010	.897
Total Variance Explained: 62%			

Results

Preliminary Demographic Analyses

A series of demographic analyses were conducted to explore the effects of gender, age, and year in school on the three dependent variables. For the frequency of the use of the learning technology, the higher the grade of the respondents, the more often was the use of the technology, $F(173) = 2.44$, $p \leq .05$. Gender and age did not affect how often the respondents used the technology.

None of the three demographic variables made a difference in the interaction dependent variable. In other words, in terms of respondents' experiences on whether the course management system facilitated interaction among students, instructors, and course materials, the differences across different gender, age, and year in school groups were not significant.

For student learning, year in school was the significant factor in determining whether students thought the course management system contributed to their learning and good grades. The higher the grade of the respondents, the more likely the participant would think that the technology helped them learn the course material better and contributed to their good grades. Gender and age did not make a difference in terms of student learning.

H1: Advantageous innovation characteristics, the adoption of the innovation, interaction, and student learning

To assess the relationship between advantageous innovation characteristics and the adoption of innovation, one correlation analysis and one multiple regression analysis were conducted. Results are presented in Table 4 and Table 5. According to Table 4, all three factors significantly correlate with the frequency of the use of the course management system (Advantage/compatibility: $r = .349$, $p < .000$; Simplicity: $r = .338$, $p < .000$; Trialability: $r = .232$, $p < .000$). To assess which one of the three factors predicted frequency better than the other factors, a multiple regression analysis was performed. Results in Table 5 show that when all three factors were entered simultaneously, simplicity was the best predictor of the frequency of usage (ß = .28, $p < .000$), followed by advantages/compatibility (ß = .22, $p < .000$). Trialibility failed to explain the variance in the dependent variable when all three factors were present. This multiple regression model explains 18% of the variance in the frequency of the use of this communication technology.

Table 4: Intercorrelations Among Variables (New window)

Table 5: **Innovation Predictors on Frequency of Usage, Interaction, and Learning**

Predictor Variable	Frequency of Usage		Interaction		Learning	
	ß	R^2	ß	R^2	ß	R^2
Advantage / Compatibility		.18***		.40***		.30***
	.22***		.58***		.57***	
Simplicity	.28***		.14*		.01	
Trialability	-.02		-.06		-.07	
*≤.05, **≤.01, ***≤.001						

The relationship between advantageous innovation characteristics and interaction was assessed by data presented in Table 4 and Table 5. According to Table 4, all three factors significantly correlate with interaction measures, with advantage/compatibility measures stand out (Advantage/compatibility: $r = .630$, $p < .000$; Simplicity: $r = .341$, $p < .000$; Trialability: $r = .277$, $p < .000$). In other words, relative advantages and compatibility, such as saving time, convenience, and compatibility with preferred work habits, contributed the most to the increased interaction among students, instructors, and course materials. Results from multiple regression analysis in Table 5 also confirm this result. When all three factors were entered together, advantage/compatibility measures are the most robust predictors of the interaction between students, instructors, and course materials (ß = .58, $p < .000$). Simplicity is also a significant predictor (ß = .14, $p < .05$). Trialability failed to predict interaction when all three factors were present. The multiple regression model explains 40% of the variance in interaction measures.

Do the advantageous innovation characteristics contribute to student learning? Correlation coefficients in Table 4 indicate that all three factors contribute to student learning (Advantage/compatibility: $r = .552$, $p < .000$; Simplicity: $r = .243$, $p < .000$; Trialability: $r = .191$, $p < .01$). Advantage/compatibility is the strongest predictor of student learning. Table 5 confirms this finding. When all three factors were entered into the multiple regression equation, only advantage/compatibility measures predict student learning (ß = .57, $p < .000$), while simplicity and trialability fail to do so. The multiple regression model explains 30% of the variance in student learning.

H2: Student characteristics and the adoption of the innovation

Two of the three hypotheses for H2 are sustained. Student motivation predicted the adoption of the innovation ($r = .248$, $p < .000$). In other words, students who were more motivated tended to use the course management system more often.

Visual, aural, and dependent learners benefit equally well from the course management system. A series of ANOVA analyses on the three learning styles generate insignificant differences in both frequency of usage and learning measures. In other words, learning styles did not make statistically significant differences in terms of how often respondents used the technology and whether they thought the technology contributed to their learning (for visual on frequency: $F(191) = .38$, $p > .05$; for aural on frequency: $F(194) = 1.32$, $p > .05$; for dependent on frequency: $F(191) = 1.15$, $p > .05$; for visual on learning: $F(190) = .81$, $p > .05$; for aural on learning: $F(193) = 1.53$, $p > .05$; for dependent on learning: $F(190) = .86$, $p > .05$).

Instructors' requirements for students to go on-line for homework and course materials did not predict the frequency of usage ($r = .048$, $p > .05$), while student motivation did.

H3: Technology related attributes and the adoption of the innovation

The hypothesized moderate correlation between technology related attributes and the adoption of innovation was not found. Results of the correlation analyses are presented in Table 4. In fact, none of the technology related measures, such as informed, interested, or computer skills, significantly correlate with the frequency of the use of the course management system. This finding actually leads to an interesting conclusion. That is, the technology is so user friendly that people who do not have moderate to high level of knowledge and attentiveness to technology can use the communication technology. In other words, similar to the finding that the technology benefits respondents with different learning styles equally well, this technology also benefits respondents with different levels of technological know-how equally well.

H4: The adoption of the innovation and interaction

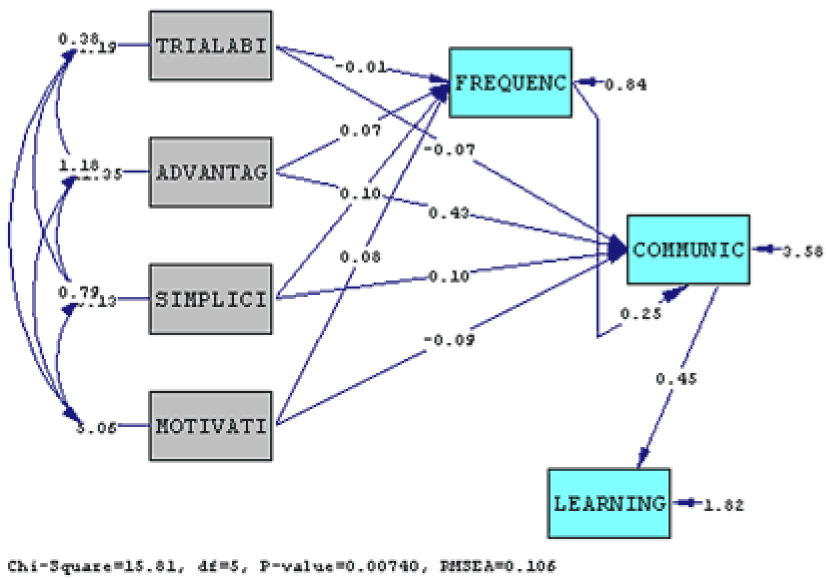
It is hypothesized that the adoption of the communication technology will facilitate interaction among students, instructors, and course materials. This hypothesis is sustained ($r = .303$, $p < .000$).

H5: Interaction and student learning

It is further hypothesized that the increased interaction between students, instructors, and course materials will contribute to student learning. This hypothesis is sustained ($r = .639$, p (.000). In fact, the correlation is quite high between interaction and student learning.

A Path Model

Based on the above sustained hypotheses, a path model was constructed to assess the direct and indirect effects among variables. The path model is based on data from Table 4. Independent variables that consistently generate significant correlation coefficients across the three dependent variables were entered into the path model as exogenous variables, which include advantage/compatibility, simplicity, trialability, and student motivation. Two of the dependent variables were conceptualized as mediators in the model: frequency of usage and interaction. Student learning is the final variable that the model is intended to explain. The path model is constructed using LISREL. The path diagram is depicted in Figure 1.



The goodness of fit of the path model was assessed by considering chi-square value and the root mean square error of approximation (RMSEA). The goodness of a path model's fit to the sample data can be judged using the following two criteria: (1) a X^2/df ratio of 5 or less (Marsh & Hocevar, 1985), and (2) an RMSEA less than or equal to .08 (Browne & Cudeck, 1993).

This model has a $X^2 = 15.81$, df = 5, $p < .01$. The X^2/df ratio for this model was 3.16, indicating an acceptable fit to the sample data. The RMSEA = .11 suggests a marginally acceptable fit, indicating that there is some room for improvement in the specification of this model. Individual path coefficients suggest that simplicity predicts the frequency of usage better than other variables. This is consistent with my previous discussion. Advantage/compatibility and student motivation also predict the frequency of usage. In predicting interaction, advantage/compatibility is by far the most robust predictor compared to the other variables (ß = .43). Collectively, the four exogenous variables accounted for 19% of the variance in the frequency of usage, and 41% of the variance in interaction. Finally, the path from interaction to student learning appears to be robust, ß = .45. All variables in this model explain 41% of the variance in student learning.

Discussion

This study sought to explain the adoption of a web-based course management system by college students using Rogers' (1995) model of the diffusion of innovation and to assess the impact of the adoption on interaction between students, instructors, and course materials. The impact of the adoption on student learning was also examined. Results indicate that Rogers' model successfully predicts the adoption of this innovation. All four factors in Rogers' model predict the adoption. When advantage/compatibility, simplicity, and trialability were entered simultaneously into multiple regression analysis and path analysis, simplicity is the most robust predictor of the adoption, which was measured as the frequency of usage. In other words, the user-friendly nature of the course management system encourages respondents to use the technology often. This finding suggests that it is important for an educational technology to have user-friendly designs for it to be used by students. Complex educational technologies will be much less likely to be adopted on college campuses. In addition to simplicity, relative advantage, compatibility, and student motivation are also significant predictors of the adoption.

Rogers' model was also used to assess the impact of technological attributes on interaction between students, instructors, and course materials. It was found that while all of the four factors in the model successfully predict interaction, the combined measure of relative advantage and compatibility is the most robust predictor of interaction. Simplicity is also a robust predictor of interaction. This finding indicates that advantageous features of the technology actually help increase the interaction between students, instructors, and course materials. The increased interaction, in turn, significantly contributes to student learning. In other words, the opportunities provided by the technology did lead to increased interaction, which directly affects student learning.

Findings in this investigation address two criticisms of Rogers' model: the individual-blame bias and the pro-innovation bias (Rogers, 1995). Individual-blame bias indicates that when something goes wrong, it is the individual to blame instead of the system. By conceptualizing student learning as the final variable in the path model, it is acknowledged that if the technology did not contribute to student learning, the system as well as the individuals are to be responsible. Moreover, nontechnological factors were included in the model, such as student motivation and interaction, so that the adoption of the course management system can be examined from a systematic perspective.

The pro-innovation bias is defined as the implication that an innovation should be adopted by all members of a social system, that it should be diffused more rapidly, and that the innovation should be neither re-invented nor rejected (Rogers, 1995). To overcome this bias, Rogers (1995) suggested examining the adoption process in broader context. As a result, contextual factors were used to address the pro-innovation bias in this study. Contextual factors include instructors' requirement, student motivation, student learning style, computer skills, whether respondents are informed about or interested in technology.

Among the four factors of Rogers' model examined in this study, although trialability alone predicted the frequency of the use of the technology, interaction, and learning, when all factors were simultaneously investigated, trialability appeared to be an insignificant predictor of frequency, interaction, and learning. One possible explanation would be that when all factors were present, the portion of the dependent variable that could be accounted for by trialabililty was explained by other factors. Because adoption was measured as an on-going process and because the adoption has already taken off, when all factors were present, relative advantage, compatibility, and simplicity stand out as more robust predictors than trialability. This finding, however, does not suggest that trialability would be irrelevant in explaining the beginning stage of an adoption process with the other factors present.

Preliminary demographic analyses for this study also show that year in school successfully predicts the frequency of the use of the technology. Moreover, the higher the grade of the participants, the more likely they would think that the technology contributes to learning. In other words, the benefits of using the technology are not immediately noticeable for participants. It takes one or two years for participants to efficiently incorporate the technology into their work habits and to realize the benefits of the technology.

The other interesting and important finding from this study is that participants with different learning styles and different technological background benefit equally well from this technology. This is great news for the manufacturer of the software and a good lesson for future manufacturers of educational technologies.

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