

The Diffusion of E-Learning Innovations in an Australian Secondary College: Strategies and Tactics for Educational Leaders

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Abstract:

This paper reports the findings of a study of teacher adoption of Web technology in a secondary college in Sydney, Australia. Data collected through a survey questionnaire was used to examine teacher perceptions regarding various attributes of the Web as a tool in both teaching preparation and delivery. Our analysis of the data suggests that the innovation adoption variables of relative advantage, compatibility, visibility, ease of use, results demonstrability, and trialability should be considered by school administrators seeking to increase the rate of adoption of e-Learning within their organisation. The image attribute did not emerge as significant in either of the contexts examined. Implications for the development of strategies for e-Learning diffusion are discussed including practical action plans developed by the school executive at our research site.

Introduction

Strategies for facilitating the adoption and effective utilisation of e-Learning are an issue of importance to educational administrators around the world. The 'information revolution' has forced most developed economies into an era which demands effective utilisation of information and communication technologies (ICT) in schools to prepare 'knowledge workers' for the 'knowledge economy' (Drucker, 1998; Maeir & Warren, 2000; OECD, 1996). As a result, educational institutions are placed in a situation requiring reassessment of their methods of practice, and necessitating adapting and improving teaching and learning for the changing needs of a global, digital, and networked economy. While global spending on ICT in educational institutions is increasing at unprecedented rates (OECD, 1998), the pressing problem for educational administrators is that the rate of adoption by teachers across different sectors of education has lagged significantly behind that of industry (Leidner & Jarvenpaa, 1995).

In the context of Australian schools, Gibbons (2001, p. 86) reports on a study of Web use by Australian teachers conducted in November 2000. The report indicates that while 98% of Australian teachers from K to 12 are using the Internet, most teachers are only performing basic tasks such as e-mail and undertaking research via search engines mainly for *teaching preparation*. Gibbons suggests that a lack of online content and advanced teacher training means that many are still struggling to incorporate Internet applications such as Web publishing (*for teaching delivery*) with traditional teaching methods. In this study we examine factors affecting the diffusion of the Web into the teaching preparation and delivery activities of teachers in Australian schools. We provide a framework for school principals to consider when formulating strategic plans for the diffusion of Web technology throughout the teaching and learning context. Specifically, we utilise Rogers' (1995) *diffusion of innovations* (DOI) theory to examine factors affecting the adoption and utilisation of the *World Wide Web* (Web) by teachers for purposes of *teaching preparation and teaching delivery*. Operationalising these factors in a school setting will assist educational administrators in strategic planning for ICT implementation including: the

design and planning of educational technology courses; ICT resource and infrastructure planning; and in the design of improved methods of professional evaluation and assessment (Stefl-Mabry, 1999).

Theory Development

Research on Attributes of ICT Innovations

Over the last two decades considerable research has been conducted into individuals' adoption of new technology in a variety of settings (Bradley, 1997; Davis, 1989, 1993; Moore & Benbasat, 1991; Taylor & Todd, 1995; Warshaw & Davis, 1985; Venkatesh, 1999; Venkatesh & Davis, 1996; Venkatesh & Morris, 2000). Much of the research in this field draws on Fishbein and Ajzen's (1975) *theory of reasoned action* (TRA). TRA posits that an individual's behaviour is a function of both the individual's attitude toward a specific behaviour and the social influences and norms surrounding that behaviour.

Consistent with the TRA, Rogers' (1995, pp. 15-16) DOI theory defines five attributes or characteristics of innovations which influence an individual's attitude towards an innovation during the adoption process. These attributes include relative advantage, compatibility, complexity, trialability, and observability. *Relative advantage* is the degree to which an innovation is perceived as better than the idea it supersedes. *Compatibility* is the degree to which an innovation is perceived as being consistent with the existing values, past experiences, and media of potential adopters. *Complexity* is the degree to which an innovation is perceived as difficult to understand and use. *Trialability* is the degree to which an innovation may be experimented with on a limited basis. *Observability* is the degree to which the results of an innovation are observable to others. Drawing directly on DOI theory and TRA, Moore and Benbasat (1991) developed an instrument to measure an individual's perceptions concerning the attributes of an information and communication technology innovation. Moore and Benbasat renamed Rogers' complexity construct *ease of use*, consistent with Davis (1989), reflecting the dominant measurement paradigm in ICT research. They also developed the *image* construct which was defined as "the degree to which use of an innovation is perceived to enhance one's image or status in one's social system" (Moore & Benbasat 1991, p. 195). According to Moore and Benbasat, Rogers included the essence of the image construct in his definition of relative advantage. However, research indicating that it was separate from relative advantage was strong enough for Moore and Benbasat to decide to measure it as a separate construct. Also, during the process of developing the instrument, Moore and Benbasat found that the construct of observability separated into two constructs: *results demonstrability* and *visibility*. *Results demonstrability* "concentrated on the tangibility of using the innovation, including their observability and communicability" (1991, p. 203). *Visibility*, on the other hand, focused on the physical presence of the innovation in the organisational setting.

Rogers' (1995) suggests that the Moore and Benbasat instrument will be a valuable tool for future research in the diffusion of technology innovations. Rogers further recommends that the use of consistent instruments or measures of innovation attributes across various settings will provide a significant contribution to innovation diffusion research. Rogers (1995, p. 204) discusses the importance of utilising this approach in various settings and points out that while much effort has been spent in studying people related differences in innovativeness, relatively

little effort has been devoted to analysing innovation differences (that is, in investigating how the attributes of innovations affect their rate of adoption). In summary, the ICT adoption variables measured by the Moore and Benbasat instrument were utilised in this present study and include relative advantage, compatibility, image, ease of use, results demonstrability, visibility, and trialability.

The Web as an Innovation in Schools

Rogers defines an innovation as “an idea, practice, or object that is perceived as new by an individual...” (1983, p. 11). He points out that ‘newness’ is not an objective measure based on time lapsed since its first use or discovery, rather, it is a subjective perception, if the idea, practice, or object seems new to the individual, it is an innovation.

Rogers defines *rate of adoption* as “the relative speed with which an innovation is adopted by members of a social system.” (1995, p. 250). DOI theory posits that the rate of adoption of an innovation is influenced by the following sets of factors: (1) the individual’s perception of the attributes of the innovation; (2) the nature of the communication channels diffusing the innovation; (3) the nature of the social system; (4) the extent of change agents’ efforts in diffusing the innovation.

Research on the *adoption* of innovations is concerned with an individual’s behaviour during the innovation diffusion process, as opposed to diffusion research per se, which focuses on the social system as a whole. Consequently, adoption can be viewed as a subset of the diffusion process, but one that takes place at the individual level rather than at the social group level. Of relevance to this present investigation is that Moore and Benbasat (1991) designed their instrument to capture user perceptions about using the innovation, which differs from Rogers’ (1995) framework which focuses on the user perceptions of the innovation itself. According to Moore and Benbasat “...it is not the potential adopters’ perceptions of the innovation itself, but rather their perceptions of using the innovation that are key to whether the innovation diffuses” (1991, p. 196). Therefore in this present study we are not concerned with teachers’ perceptions of the Web per se, but we are concerned with teachers’ perceptions of using the Web in a variety of work-related contexts. The hypotheses tested in this study are therefore as follows:

Hypothesis 1:

The seven ICT adoption variables (relative advantage, compatibility, image, visibility, ease of use, results demonstrability, and trialability) will predict the dependent variable, teachers’ future use of the Web for the purpose of *teaching preparation*; and

Hypothesis 2:

The seven ICT adoption variables (relative advantage, compatibility, image, visibility, ease of use, results demonstrability, and trialability) will predict the dependent variable, teachers’ future use of the Web for purposes of *teaching delivery*.

Data Analysis and Results

All 75 teachers from the participating secondary college in Sydney, completed a questionnaire survey which included the items from the short form of the Moore and Benbasat (1991) instrument and some demographic questions. All questionnaires were completed and useable

thus satisfying our sample size requirements for the statistical analysis and also eliminating concerns relating to non-response bias.

The demographic data revealed that the sample comprised a balanced spread in terms of gender (51% female), and age (32% <29 yrs, 33% 30-44yrs, 35% > 44yrs). The sample also demonstrated that the majority (80%) of teachers had completed at least 4 yrs of post-secondary education studies. Finally, the sample represented all nine key learning areas offered by the school. In order to test the hypotheses, the hypothesised linear relationships were modelled with a multiple regression model.

The questionnaire items measuring teacher perceptions relating to each of the seven ICT adoption variables were adapted from the Moore and Benbasat (1991) instrument. Following pilot surveys and discussions with the school Principal some changes were recommended to the questionnaire by the school Principal due to their repetitiveness and/or lack of relevance to Web use in the school learning and teaching context. The *ease of use* construct was reduced from 4 items to 3 items and one of the items was changed to include the ease of implementation, which the Principal regarded as an important aspect of ease of use in the context of this study. The *image* construct was also reduced from 3 items to 2 items associated with increased prestige or status resulting from use of the Web in teaching. The *results demonstrability* construct was reduced from 4 items to 2 items relating to the ease of observing and explaining the results of using the Web in teaching. No modifications were made to the items *measuring relative advantage*, *compatibility*, *trialability*, and *visibility*. In summary, a total of 19 questionnaire items comprising seven multi-item scales were used to measure the *independent variables* in this study. Two single item measures asking teachers about their intended future use of the Web, for (a) *teaching preparation* and (b) *teaching delivery*, were utilised to measure the dependent variables in this study. All items were measured on a seven point Likert scale with polar anchors “strongly agree” and “strongly disagree”.

Mean scores were calculated from the summated responses to the items forming each independent variable (Spector, 1992). The Moore and Benbasat (1991) instrument has been used extensively in the literature demonstrating reliability and validity in a range of contexts (see Bradley, 1997). In this study Cronbach’s (1951) alpha was used to assess the internal consistency reliability of each of the seven the ICT adoption variables. The results indicate that all variables displayed similar results for internal consistency reliability as the original form of the instrument developed by Moore and Benbasat (1991). To establish the construct validity of the instrument used in this study factor analyses were performed using the principal components method of analysis. Again, our results were similar to those of Moore and Benbasat with the items loading onto six distinct factors. All loadings were in the good to excellent range (Comrey, 1971) providing further support for the instrument used in this study.

Hypothesis 1: Web Use for Teaching Preparation

A multiple regression analysis (full model) was conducted of all seven ICT adoption variables on the dependent variable *Web use for teaching preparation* (TPREP). The results indicate strong support for Hypothesis 1 (see Table 1). The full model regression equation was statistically significant ($p < .0001$) and explained approximately 74% of the variation in TPREP ($R^2 = .744$). Model reduction techniques (Tabachnick & Fidell, 2001) were then used to formulate a reduced

model including only the significant variables of relative advantage, results demonstrability, and trialability.

The results indicate (see Table 1) that the reduced model regression equation was statistically significant ($p < .0001$) and there was no significant difference between the full and reduced model in terms of their ability to explain variation in TPREP ($R^2 = .734$). The results also indicate that relative advantage, results demonstrability, and trialability have a positive and significant relationship with TPREP.

Various tests were also conducted to check the regression assumptions of normality, linearity, and homoscedasticity of residuals (Tabachnick & Fidell, 2001). The tests revealed that in both cases the regression assumptions had not been seriously violated.

Table 1: Results of multiple regression of ICT adoption variables on TPREP.

VARIABLES	Full Model (7 factors)			Reduced Model (3 Factors)		
	Beta	t	p – value	Beta	t	p – value
Constant	.723	1.97	.053	.758	2.23	.029
Relative Advantage*	.288	1.90	.062	.376	3.85	.000
Compatibility	.074	.57	.570			
Image	-.065	-.99	.327			
Visibility	.089	1.17	.247			
Ease of use	.060	.57	.572			
Results demonstrability*	.285	2.53	.014	.344	3.49	.001
Trialability*	.205	2.54	.013	.203	2.57	.012
Variance (R2)		.744			.734	
Adjusted R2		.718			.723	
Significance of F p-value		.000			.000	
* Denotes inclusion of variable in both full and reduced regression models.						

Hypothesis 2: Web Use for Teaching Delivery

A multiple regression analysis (full model) was conducted of all seven ICT adoption variables on the dependent variable Web use for teaching delivery (TDEL). The results indicate strong support for Hypothesis 2 (see Table 2). The full model regression equation was statistically significant ($p < .0001$) and explained approximately 58% of the variation in TDEL ($R^2 = .575$). Model reduction techniques (Tabachnick & Fidell, 2001) were then used to formulate a reduced model including only the significant variables of compatibility, visibility, and ease of use.

The results indicate (see Table 2) that the reduced model regression equation was statistically significant ($p < .0001$) and there was no significant difference between the full and reduced model in terms of their ability to explain variation in TPREP ($R^2 = .565$). The results also indicate that *compatibility*, *visibility*, and *ease of use* have a positive and significant relationship with TDEL.

Various tests were also conducted to check the regression assumptions of normality, linearity, and homoscedasticity of residuals (Tabachnick & Fidell, 2001). The tests revealed that in both cases the regression assumptions had not been seriously violated.

Table 2: Results of multiple regression of ICT adoption variables on TDEL

VARIABLES	Full Model (7 factors)			Reduced Model (3 Factors)		
	Beta	t	p – value	Beta	t	p – value
Constant	1.04	2.02	.048	1.15	2.72	.009
Relative Advantage* X1	-.227	-1.06	.82			
Compatibility* X2	.499	2.74	.067	.400	3.11	.003
Image X3	-.006	-.07	.546			
Visibility* X4	.217	2.02	.037	.197	2.14	.036
Ease of use* X5	.344	2.30	.033	.326	2.81	.006
Results demonstrability X6	.063	.40	.874			
Trialability X7	.050	.44	.793			
Variance (R2)	.575			.565		
Adjusted R2	.531			.547		
Significance of F p-value	.000			.000		
* Denotes inclusion of variable in both full and reduced regression models.						

Implications for E-Learning Diffusion

As hypothesised our empirical results show that DOI theory as operationalised in this study was successful in predicting the future Web use by teachers for purposes of teaching preparation and teaching delivery. An interesting aspect of the results was that in each case of Web use by teachers three *different* DOI factors emerged as significant. Of further interest to school principals is the fact that image did not emerge as a significant factor in either of the cases. This finding indicates that strategies that promote the status (or image) of teachers who are currently advanced in their use of the Web is not likely to have effect the adoption behaviours of other teachers. Principals seeking to increase the rate of adoption of the Web by teachers will be better served adopting strategies that address the attributes of the Web found to be significant in this study.

In the case of Web use for teaching preparation the three most important factors affecting teachers in our sample were relative advantage, results demonstrability, and trialability. This finding suggests that in the context of our sample, strategies to increase the adoption of teachers' use of the Web for teaching preparation should specifically address these attributes. While in the case of Web use for teaching delivery, strategies should focus on the attributes of compatibility, visibility, and ease of use. The following discussion provides some examples of how this may be achieved.

Strategies for Increasing Web use for Teaching Preparation

Relative advantage was concerned with the degree to which using the innovation is perceived as being better than using the present method. The term better relates to factors such as quality, efficiency, and effectiveness. Thus, one strategy to increase adoption in this context is to organise professional development programs that require teachers to prepare a lesson on the same topic using the present method followed by a lesson using the Web. Teachers could then be asked to evaluate each lesson in terms of efficiency (ie. time spent), and the quality and effectiveness of the final lesson plan.

Results demonstrability represents the extent to which use of the Web provides teachers with clear, measurable, and observable results. In the case of teaching preparation the results are evident in the final lesson plan and the reaction of students. Therefore in the context of our sample, teachers should be encouraged to formally evaluate lessons that have been prepared with and without the use of the Web. For example, a survey of student satisfaction at the end of each of these lessons may provide the teacher with greater insight and clear evidence regarding the results of using the Web when preparing lessons. In addition, school principals could provide teachers with the latest research on student learning in technology rich environments.

Trialability represents the extent to which teachers can trial the use of the Web in teaching preparation prior to adoption. One strategy for increasing the trialability of the Web for teaching preparation is to provide teachers with convenient access to the Web in places where they are most likely to perform this activity. At school these areas would include staffrooms, common rooms, and classrooms. It is also common for teachers to prepare lessons at home and therefore any scheme that subsidises teachers for the costs of Web access from home would increase opportunities for trialing the Web. Good quality peripheral devices, such as colour laser printers and screen projectors, should also be available for teachers to trial when using the Web to prepare lessons. Trial agreements with vendors of e-Learning related products and services could

also be utilised to assist in this process. Finally, professional development days providing opportunities and advice for teachers to trial the Web for teaching activities would be beneficial in this context.

Strategies for Increasing Web use for Teaching Delivery

Compatibility represents whether or not the innovation is perceived to fit teachers' existing values, needs, and past experience. In the context of our study, the move to teaching delivery through the Web represents a dramatic shift from the traditional face to face teaching methods familiar to teachers. Organisational strategies will need to target this problem in order to increase teacher perceptions regarding the compatibility of this non-traditional teaching mode within their context. Teachers could be supported in this regard through professional development regarding the pedagogical implications of e-Learning. Radical structural changes may also assist increasing the compatibility of Web-based teaching in the traditional school environment. For example, school policy currently requires students and teachers to attend each class in the traditional mode. This policy creates an inherent structural limitation for the diffusion of Web-based teaching delivery. That is, any Web-based delivery will need to be conducted over and above the current workload of both groups. As such, one organisational strategy to overcome this problem may be the rescheduling of the school timetable in order to facilitate a mixed delivery mode.

Visibility examines how apparent or visible the use of the innovation is in the organisation or school context. In the context of our sample, Web use for teaching delivery is a *relatively more recent innovation* than Web use for teaching preparation. At this early stage, increasing the rate of adoption of this innovation will require strategies that promote the physical presence of the innovation throughout the school. For example, vendors of Web-based delivery products could be invited by the school Principal to promote their products at staff meetings and most importantly provide sample content for teachers to access on the school network. The school principal could also identify teachers in other schools involved in best practice in this area and invite these teachers to the school to share their experiences.

Ease of use is concerned with the ease of using, learning, and implementing the innovation. In the context of our sample, Web-based teaching delivery is relatively new to teachers and at this stage they may be unfamiliar with the technologies supporting this mode of learning. As such, the school principal may adopt a number of strategies to assist teacher perceptions during this initial phase including increased time for professional development, the employment of competent e-Learning resource developers, and the provision of adequate user-friendly infrastructure to facilitate the implementation process. Another important strategic consideration is the identification and acquisition of existing e-Learning resources suitable to the teaching and learning context of the school. This process will allow teachers to build on existing modules thereby reducing difficulties of implementation.

Conclusions and Future Research

The findings in this study indicate that school principals seeking to increase the rate of Web use by teachers should consider the various activities being supported by the Web and develop separate strategies for each situation. When developing these strategies principals can utilise DOI theory and specifically consider teachers' perceptions regarding the attributes associated with using the Web in various teaching and learning contexts. The discussions above provide various

examples and suggestions of how this framework may be utilised in the development of strategic plans for the integration of e-Learning in schools including: the design and planning of educational technology courses; e-Learning resource acquisition; and ICT infrastructure planning.

While this study investigated the adoption of the Web from the perspective of teachers, future research utilising the same methodology could consider adoption from the perspective of students. Future studies could also utilise the same methodology employed in this study to investigate other applications of ICT in schools or even other applications of the Web such as use of the *Web for assessment* purposes.

As the research design utilised in this study is susceptible to common method variance, it would therefore be beneficial if future studies could utilise a multitrait-multi-method design (see Kline, Sulsky & Rever-Moriyama, 2002). Also, future studies incorporating a longitudinal design may provide deeper insight into the complex underlying interactions involved during the e-Learning diffusion process. For example, the introduction of a new e-Learning technology into a school district could be examined at various stages throughout the implementation process to ascertain the stability or otherwise of teacher perceptions regarding the innovation attributes examined in this study.

In summary, the theoretical framework utilised in this study provides a rich and potentially fruitful area for further research and has practical implications for teachers, educational administrators, and vendors concerned with the diffusion of e-Learning in traditional educational institutions.

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