Chapter 1

Introduction

"The collective knowledge about the diffusion process is less than it otherwise might be. To move beyond the current state of knowledge, investigators must begin to ask questions that have not been answered"
Meyer, G. (2004). Diffusion methodology: Time to innovate? *Journal of Health Communication, 9*, 59-69.

This chapter describes a problem facing schools when they adopt technology, examines its impacts, and proposes a solution grounded in diffusion of innovation (DOI) theory as synthesized by Rogers (2003). The chapter also includes an introduction to the pertinent components of DOI theory, integrates recent critiques of the theory, and describes how the proposed solution was examined. The chapter concludes with the research questions that guided the study.

The Problem Facing Schools When They Adopt Technology

While the number of research studies that provide evidence of the significant, positive impacts of technology in our nation's K-12 classrooms is large and growing (Waxman, Connell, & Gray, 2002; Waxman, Lin, & Michko, 2003), research on methods that predict the success of a technology prior to adoption lag behind. While well-conceived instruments and methods exist for informing the technology implementation process (Hord, Rutherford, Huling-Austin, & Hall, 1987) and for assessing and evaluating teachers' uses of technology (Moersch, 1995), these instruments are only of use *after* a school or district has expended resources on hardware, software, and professional development in order to bring a technology innovation into the classroom.

School districts are often faced with the prospect of expending large sums of money on computer hardware, software, and staff development without information that could guide their choices or, at least, assist them in the design of strategies to increase the likelihood that the technology will be used as planned. The adoption of a new computer-supported reading curriculum by the Los Angeles, California Unified School District (Guerard, 2001; Helfand, 2005) is a case in point.

The Impact of the Problem

In July, 2001 Los Angeles Unified School District purchased a computer-supported reading curriculum and over 6,000 computers at an approximate cost of $44 million (Guerard, 2001). Just over fifty-seven percent of the district's kindergarten and first-grade classrooms, serving more than 81,000 students, were equipped with the curriculum. The purchase announcement was accompanied by great expectations for increasing students' reading skills (Guerard, 2001). Two years into the project an evaluation performed by the district's internal evaluation staff (Hansen, Llosa, & Slayton, 2004) found no significant differences in reading performance between students in classrooms with the new curriculum and those students in classrooms without it. This result was primarily attributed to teachers' low level of use, and reported usage levels were between one-third and one-half of the expected amount (Hansen, Llosa, & Slayton, 2004). Other multi-million dollar technology initiatives have recently ceased mid-implementation due to improper implementation and lack of significant results (Murray, 2005) or have been cancelled prior to deployment due to inadequate leadership (eSchool News, 2005b). The significance of these disconnects between costs and results cannot be understated given the size of these expenditures and the variety of unmet needs in school

districts. In the case of Los Angeles Unified, the $44 million spent on the project could have "built three new elementary schools, kept primary grade class sizes at 20 students for a year, or refurbished all middle and high school science labs" (Helfand, 2005, p. A-1).

There continues to be great uncertainty about the outcome of expenditures for learning technology and to date, learning technology research has not investigated ways to reduce that uncertainty. The field's research inquired into how teachers use the technology they have already adopted (Beck & Wynn, 1998; Cuban, 2001; Hadley & Sheingold, 1993; Huerta, 2002; Huggins, 2002; Hughes, 2000; Waxman, Connell, & Gray, 2002; Waxman, Lin, & Michko, 2003), modeled teachers' technology-learning processes (Hughes, 2003), described technology-using teachers (Becker, 1994; Hadley & Sheingold, 1993), and identified characteristics of teachers associated with increases in the frequency of use of technology (Marcinkiewicz, 1994; van Braak, 2001; Vannatta & Fordham, 2004; Zhao & Frank, 2003; Zhao, Pugh, Sheldon, & Byers, 2002). No research examines how teachers perceive learning technologies *before* they are purchased and if those perceptions factor into their decision to adopt or reject a particular technology innovation. Practical models of teachers' adoption decision making and reliable data collection and analysis methods that can indicate technology adoption would be a contribution to practitioners and learning technology researchers seeking to increase the effective use of technology in schools.

Diffusion of Innovation Theory

A solution to this problem may be found in a field of research called the diffusion of innovations (DOI), which has provided information on how innovations of all types are adopted by populations worldwide for over sixty years. As mentioned in Rogers (2003), DOI theory has its origins in 1943 with Ryan and Gross' study of the adoption of corn hybrids by Iowa farmers. Since then, DOI research has grown to be a body of scholarly inquiry encompassing thousands of studies. Everett Rogers, the foremost DOI scholar and author of the definitive text in the field (Rogers, 2003), defines an innovation as "an idea, practice, or object that is perceived as new by an individual or other unit of adoption" (p. 475). DOI theory describes the path that innovations take from their first inception in the minds of their creators through to their adoption and use by organizations and individuals. While those portions of the theory that describe the process by which innovations come into existence lie outside the scope of the present study, the portion of DOI theory that undergirds this study is encompassed by Rogers' model of the innovation-decision process. Rogers' model of the process is illustrated in Figure 1 and is defined as "the process through which an individual (or other-decision making unit) passes from first knowledge of an innovation, to forming an attitude toward the innovation, to a decision to adopt or reject, to implementation of the new idea, and to confirmation of this decision" (p. 170).

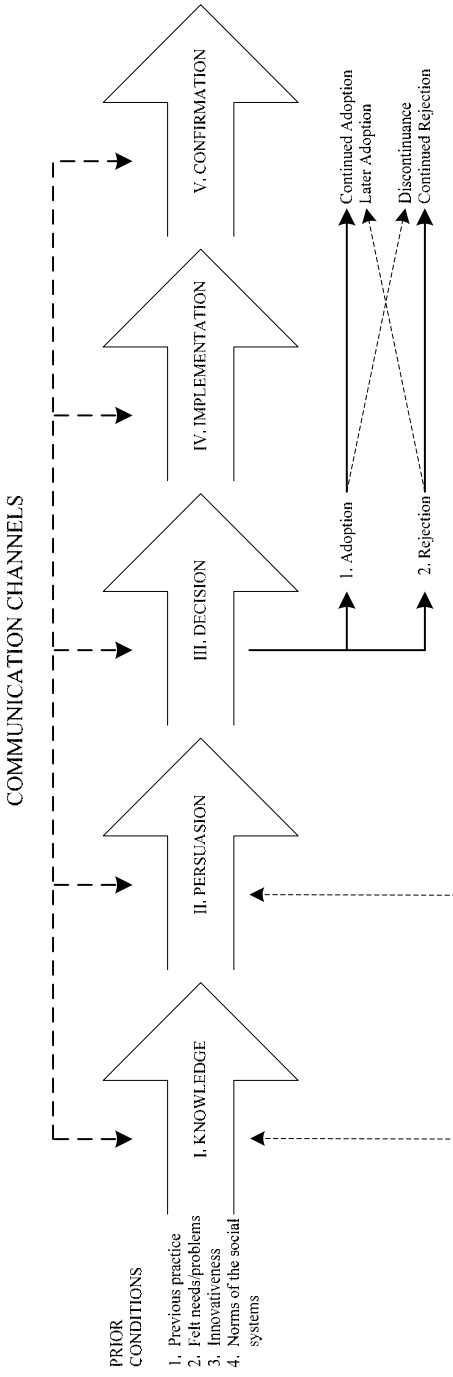

Figure 1: Rogers' model of the innovation-decision process.
Note. From *Diffusion of Innovations, 5th Edition* by Everett M. Rogers (F 5-1, p. 170).

First popularized by Ryan and Gross (1943), each of the stages is summarized as follows. The knowledge stage begins when the decision making unit (organization or individual) comes to know about the innovation and begins to understand its functions. During the persuasion stage the individual forms an attitude, favorable or unfavorable, toward the innovation. The decision stage is reached when the activities of the individual or organization lead to the choice to adopt or reject an innovation. Implementation occurs when the innovation is put to use, and the confirmation stage is characterized as the individual or organization seeking reinforcement for the adoption decision already made (Rogers, 2003).

It is important to distinguish how the term *adoption* in use in much of the learning technology research literature is distinct from its use in DOI theory and hence the present study. In the educational change literature, adoption is often attached to some description of a process through which teachers learn to use technology, or some other innovation, and then modify their teaching practice as a result. The process can be staged-based (Hadley & Sheingold, 1993; Sandholtz, Ringstaff, & Dwyer, 1997) or non-linear (Hughes, 2000, 2003) but essentially adoption is considered to be a change process that occurs over time. Instruments based on the Concerns-Based Adoption Model (CBAM) (Hord, Rutherford, Huling-Austin, & Hall, 1987) are often used to gather data on technology adoptions and other school changes as they occur, and effective models of assessing where teachers fall within various technology adoption stages have also been developed (Moersch, 1995).

In the present study the definition of adoption is taken from DOI theory and simply describes one of two possible outcomes of the decision step of Rogers' (2003)

innovation-decision process. Rogers' defines adoption as "the decision to make full use of an innovation as the best course of action available" (p. 473) and rejection as "the decision to not adopt the innovation" (p. 476).While there are prior conditions and other innovation-decision stages before the decision stage, the decision stage itself is treated as a straight-forward choice between adoption and rejection. Implementation, the next stage in Rogers' innovation-decision process model, encompasses much of what the learning technology literature calls the adoption process.

There is good reason for the way learning technology researchers have defined adoption as a process rather than a decision. Schools sometimes are engaged in an innovation adoption dilemma because adoption decisions often occur on multiple levels. Two constructs are proposed to describe this dilemma. Districts first make *macro-adoption* decisions. Macro-adoptions of technology innovations are signified by expenditures for some combination of computer hardware, software, and/or professional development. But the purchase of any innovation, technological or otherwise, by a school board does not guarantee that teachers will "make full use" of the innovations delivered to their classrooms. Further *micro-adoption* decisions must be made by individual principals and teachers before impacts on students can begin to appear (Tornatzky & Fleischer, 1990). The case of the Los Angeles Unified School District's deployment of a $44 million computer-supported reading curriculum is an example of the *macro/micro adoption dilemma*. The school board made the macro-adoption when they purchased an innovation (the new computer-based curriculum) from the vendor. Teachers were then relied upon to make separate, subsequent micro-adoption decisions to use the curriculum. The innovation's implementation was less than the district had planned, which in the

context of DOI theory means the innovation did not diffuse through the population as the teachers did not make "full use" of the innovation.

Criticisms of Diffusion of Innovations (DOI) Research

While DOI theory provides the theoretical frame for the present study, DOI research is not without its flaws. In the overwhelming majority of DOI studies, the same methods as Ryan and Gross (1943) are used. This repetitious use of methods has been criticized by innovation diffusion researchers in the past (Rogers, 1995; Tornatzky & Klein, 1982) and more recently (Chin & Marcolin, 2001; Meyer, 2004; Rogers, 2003) because this dominant methodology relies on "quantitative data, concerning a single innovation, collected from adopters, at a single point in time, after a widespread diffusion had already taken place" (Meyer, 2004, p. 59). Meyer summarizes the limitations of this methodology:

> In sum, then, a great deal is known about the characteristics or attributes of innovations, about the characteristics of adopters, and whether or not and when adoption occurred. Importantly, however, much less is known about ''why'' or ''how'' adoption occurs or fails to occur (pp.62-63).

This gap in what we know from DOI research means that DOI theory is of less use than it could be, especially when the theory is used to guide or understand the micro-adoptions of teachers.

Meyer (2004) specifically calls for the inclusion of additional methods to address two weaknesses stemming from the use of the dominant methodology: (a) the reliance on what Rogers (2003) calls *postdiction* and (b) the disregarding of post-adoption outcomes. According to Rogers, postdiction is a form of generalization, and it occurs when

researchers use results from research on already-diffused innovations as they attempt to predict the rate of adoption for (a) the same innovation in another population or (b) a different innovation. Postdiction is weakened by two problems that are inherent in studying already-diffused innovations: (a) the pro-innovation bias problem that results when researchers rely on adopters alone as data sources, ignoring data from non-adopters; and (b) the recall problem, where researchers rely on participants to recall information on when and why they adopted the innovation. The recall problem is especially difficult to overcome when examining the behaviors of those who adopted the innovation first, and, as these first adopters often have the greatest impact on an innovation's rate of adoption, they are of most interest to researchers. Meyer (2004) describes the impact of the recall and pro-innovation bias problems:

> More information exists about what adopters think happened in the diffusion process than exists about what actually happened in the diffusion process… much more is known about how important aspects of the diffusion process are associated or correlated with each other than is known about how such important aspects are causally related to each other (pp. 62-63).

Thus the recall and pro-innovation bias problems increase the uncertainty in the conclusions of DOI research, again reducing their usefulness when developing innovation adoption strategies.

DOI research routinely disregards post-adoption outcomes, and this stance is embodied in research designs that simply stop collecting data after a decision to adopt has been reached (Tornatzky & Klein, 1982) or use *shallow usage measures* that Chin and Marcolin (2001) define as measures that rely on simple reports of frequency of use or

duration of use. Designs that use shallow usage measures (Bussey, Dormody, & VanLeeuwan, 2000; Marcinkiewicz, 1994; Moore & Benbasat, 1991; van Braak, 2001; Vannatta & Fordham, 2004) ignore why an innovation is used (or not) and its impact. The result of disregarding post-adoption outcomes, according to Meyer (2004), is that "a great deal, for example, is known about the extent of innovation adoption but much less is known about…the actual way in which the innovation is used" (p. 62). Without measures that go beyond frequency and duration, the real impact of using an innovation is unknown.

These two weaknesses in the dominant DOI research methodology (i.e., reliance on postdiction and the disregarding of post-adoption outcomes) impact K-12 schools by reducing the usefulness of DOI theory to school leaders. Currently, if school leaders use DOI research, then a reliance on postdiction and a disregard for post-adoption outcomes means they lack quality indicators for how a micro-adoption could proceed. Without quality indicators, school leaders may pursue insufficient or inappropriate diffusion strategies as they attempt to increase teachers' micro-adoptions. Worse, school leaders may make a macro-adoption decision to purchase an innovation ill-suited for micro-adoption by teachers, thereby wasting resources better expended elsewhere. The present study intends to address this problem through the development and initial use of the Innovation Adoption Profile (IAP), a predictive model of teachers' micro-adoption decision making.

The Innovation Adoption Profile (IAP)

The present study relies on DOI theory to propose and investigate the initial use of the Innovation Adoption Profile (IAP), a model designed by the researcher to indicate

(a) the outcome of teachers' micro-adoption decisions, and (b) the possible post-adoption outcomes of using a technological innovation. The IAP uses surveys and interviews to collect data from teachers in situations where macro-adoptions of technology innovations are being considered, thereby providing school leaders with information on the indicators of teachers' micro-adoption and the possible post-adoption outcomes.

Specifically, the IAP models teachers' micro-adoptions and post-adoption outcomes in separate stages, one on either side of the decision stage in Rogers' (2003) model. Stage 1 uses three of the inputs depicted in Rogers' model of the innovation-decision process in Figure 1 when indicating teachers' micro-adoptions: the prior conditions called *innovativeness* and the *norms of the social system*, and the persuasion stage input called the *perceived characteristics of the innovation*. Stage 2 describes the post-adoption outcomes of using the innovation by collecting interview data related to *deep usage* (Chin & Marcolin, 2001). Deep usage goes beyond the shallow usage measures mentioned earlier to include descriptions "more tightly coupled to the actual act of technological use" (Chin & Marcolin, 2001, p. 10). Stage 2 data will be collected by interviewing innovation-adopting teachers and analyzed using the Replacement-Amplification-Transformation (RAT) taxonomy developed by Hughes (2000). The RAT taxonomy conceptualizes "three categories of technology use in content areas: technology as replacement, technology as amplification, and technology as transformation" (Hughes, 2000, p. 1). The RAT taxonomy is more fully described in the methods section.

Innovativeness is defined by Rogers as "the degree to which an individual or other unit of adoption is relatively earlier in adopting new ideas than the other members of a system" (Rogers, 2003, p. 475). While this definition seems both time- and

innovation-bound, Hurt, Joseph, and Cook (1977) cite Rogers and Shoemaker's (1971) characterization of individual innovativeness as a generalized personality trait and propose that it is a "normally distributed, underlying personality construct, which may be interpreted as a willingness to change" (Hurt, Joseph, & Cook, 1977, p.59). Hurt et al.'s definition of innovativeness as willingness to change has been used in studies describing the dispositions of technology-using teachers (Baylor & Ritchie, 2002; Marcinkiewicz, 1994; Vannatta & Fordham, 2004) and will be used in the present study. In addition, three demographic attributes that "may have constituted proxy variables for willingness to take risks" (Tornatzky & Fleischer, 1990 , p. 192) are included in the innovativeness component of the IAP. These are age, level of educational attainment, and number of career-related job changes.

The IAP incorporates self-reports of innovativeness as an independent variable in two ways, once as individual innovativeness and again as perceived organizational innovativeness. While not explicitly depicted in Rogers'(2003) model of the innovation-decision process, perceived organizational innovativeness is incorporated into the IAP in order to capture data on another of Rogers' prior conditions for adoption of innovations, the social norms of the organization into which the innovation is being introduced.

Rogers (2003) defines the perceived characteristics of the innovation (PCIs[1]) not as a single construct, but rather as five distinct constructs. They are (a) relative advantage: the degree to which an innovation is perceived as being better than the idea it supersedes; (b) compatibility: the degree to which an innovation is perceived as

[1] This abbreviation is used when referring to the plural of the perceived characteristics of the innovation, and is pronounced "P-C-eyes."

consistent with the existing values, past experiences, and needs of potential adopters; (c) complexity: the degree to which an innovation is perceived as relatively difficult to understand and use; (d) trialability: the degree to which an innovation may be experimented with on a limited basis; and (e) observability: the degree to which the results of an innovation are visible to others (Rogers, 2003). The PCIs have seen wide use in previous DOI research in learning technology (Bussey, Dormody, & VanLeeuwan, 2000; Elliot, Foster, & Stinson, 2003; van Braak, 2001; Zhao & Frank, 2003), information technology (Carter & Belanger, 2003; D. R. Compeau & Meister, 2003; Gagliardi & Compeau, 1995; Moore & Benbasat, 1991; Zhu & He, 2002), assistive technology (Riemer-Reiss & Wacker, 2000), and other fields (Armstrong & Yokum, 2001; Edwards et al., 2004). A meta-analysis of seventy-five studies (Tornatzky & Klein, 1982) and Rogers' (2003) synthesis of hundreds of DOI studies indicate the PCIs explain between 49 and 87 percent of the variance in the rate of adoption of innovations.

The five PCIs that emerged from Rogers' (2003) synthesis of DOI research are not fixed, having been revised and expanded by researchers seeking to capture perceptions of specific innovations. For example, Rogers cites Holloway's (1977) research with one hundred high school principals who were engaged in a novel high school/university partnership. Holloway distinguished *image*, or status conferral, as a sixth PCI. More recently, others have performed more extensive revisions of the PCIs to fit it more closely to information technology innovations in general (Agarwal, Karahanna, & Powers, 1998; Agarwal & Prasad, 1997; Moore & Benbasat, 1991) and software innovations in particular (D. R. Compeau & Meister, 2003). This work informs

the present study such that the IAP includes ten PCIs, which are described in the methods section.

Stage 1 of the IAP utilizes a combination of factors that include (a) the combination of individual innovativeness and three demographic proxies, (b) individuals' perceptions of their organization's innovativeness, and (c) individuals' perceptions of ten perceived characteristics of the innovation (PCIs), to indicate teachers' micro-adoption decisions. Stage 2 uses the same factors as Stage 1 to describe the post-adoption outcomes from teachers' use of the innovation and uses deep usage data to describe those outcomes. The stages of the IAP model are illustrated using two figures because they reflect two distinct stages on either side of the decision stage in Rogers' (2003) model of the innovation-decision process. Figure 2 illustrates Stage 1 of the IAP and the role its elements play in predicting teachers' micro-adoption decisions while Figure 3 illustrates Stage 2 of the IAP and the role its elements play in predicting teachers' post-adoption use(s) of the innovation in their classrooms.

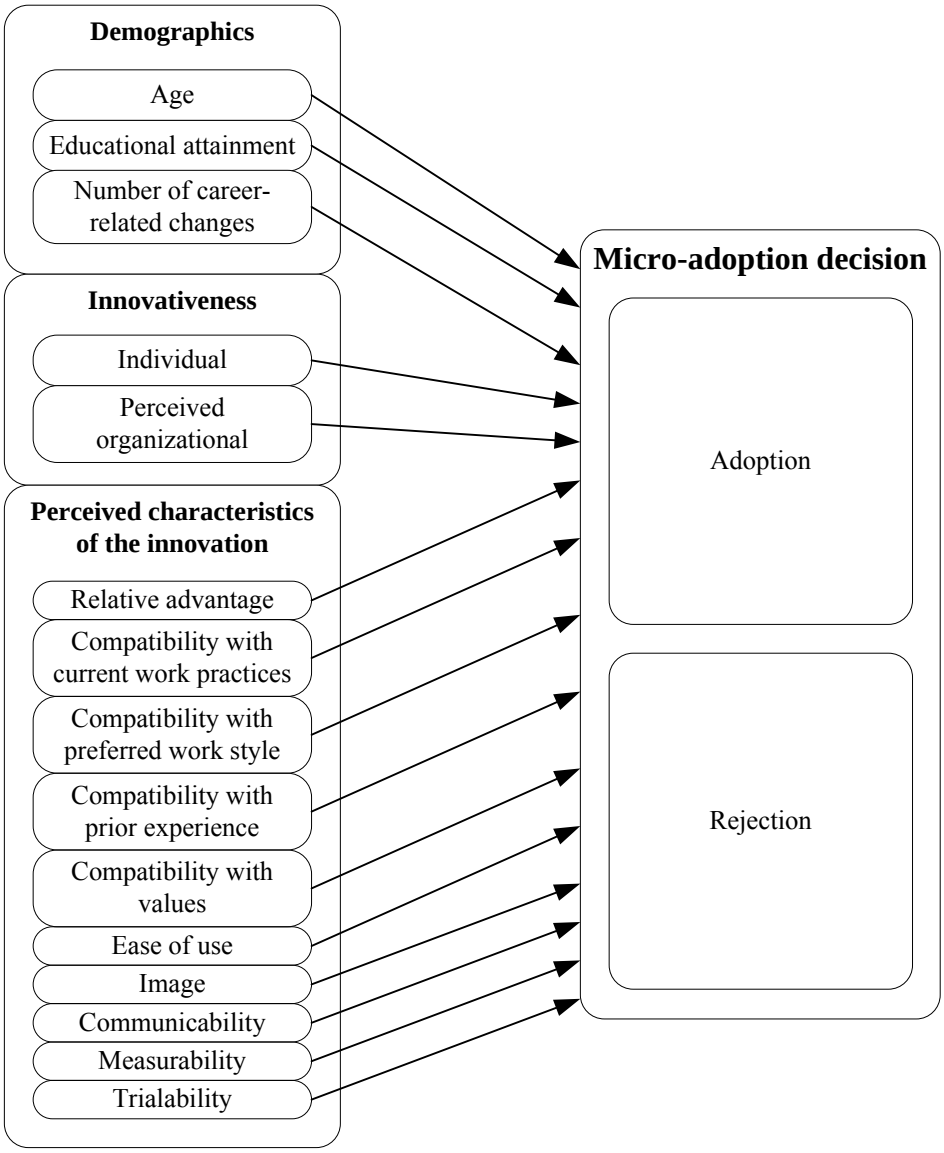

Figure 2: Stage 1 of the Innovation Adoption Profile (IAP) and the role its elements play in predicting teachers' micro-adoption decision.

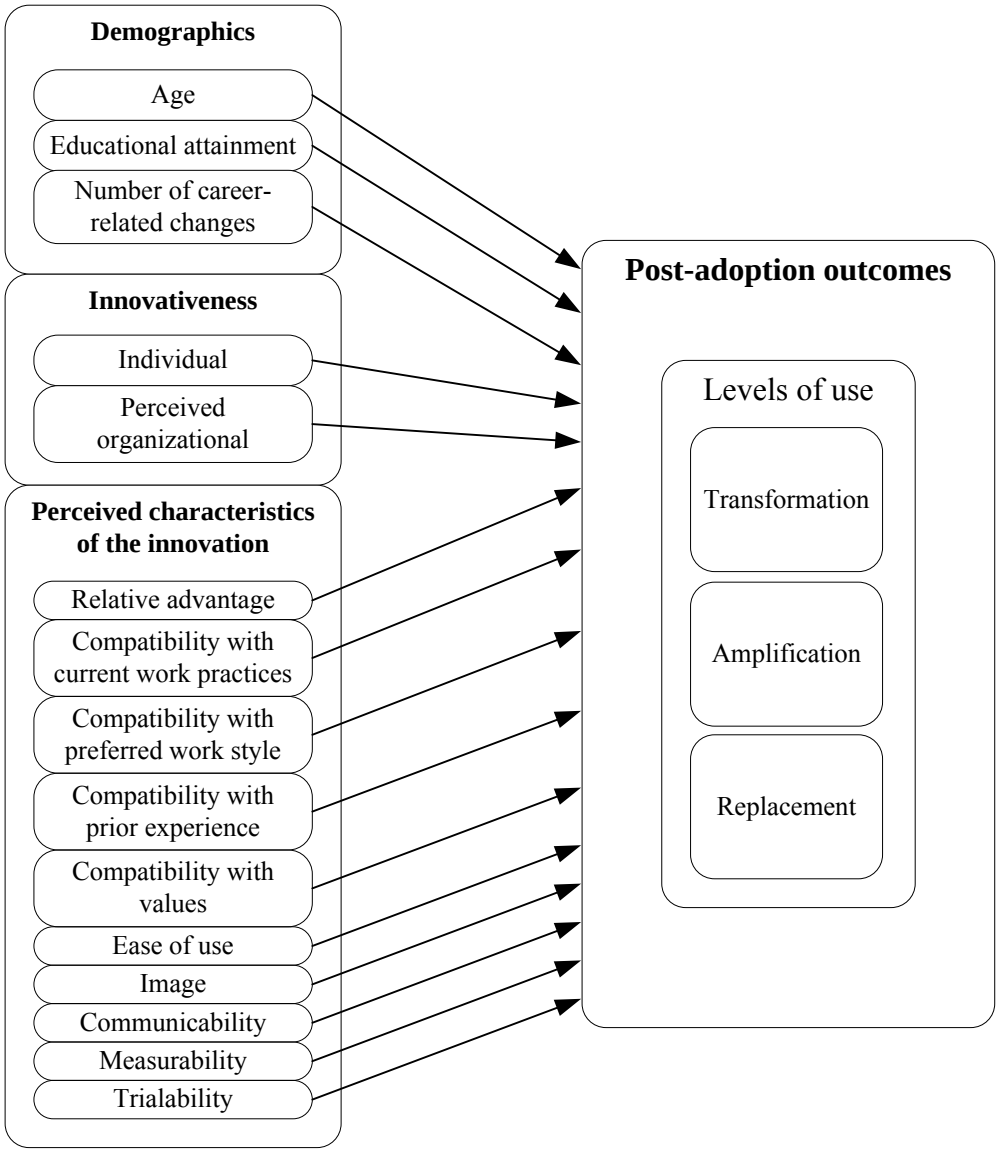

Figure 3: Stage 2 of the Innovation Adoption Profile (IAP) and the role its elements play in predicting post-adoption outcomes within the Replacement/Amplification/Transformation framework (Hughes, 2000).

Investigating the Innovation Adoption Profile (IAP) model

In keeping with the two stages of the IAP model, this study examines the model in two phases. Phase 1 will use a point-of-adoption design in the context of an introductory workshop on a learning technology innovation. Point-of-adoption designs allow DOI researchers to gather data on participants' reasons for adopting or rejecting an innovation shortly after the decision has been made, thereby avoiding the postdiction problem (Meyer, 2004). During the workshop teachers will complete the innovativeness survey, be given background information on the uses of the innovation, learn to use a software package that manifests the innovation, and complete the PCI survey. They will then be invited to participate in a four-week field trial of the software in their classrooms and their response to the invitation will be considered a micro-adoption decision. After the workshop teachers will be interviewed to hear their reasons for their micro-adoption decision. Including interviews addresses another of Meyer's criticisms, which is a lack of use of qualitative methods to "explain why certain events unfolded as they did" (p. 67).

Phase 2 of the examination of the IAP will follow teachers as they implement the software in their classrooms during the field trial. Telephone interviews were conducted as a deep usage measure to understand how teachers are using the software. This phase addresses another of Meyer's (2004) criticisms of DOI research by investigating the post-adoption outcomes of teachers' use of the software in their classrooms.

The Innovation Used in This Study

To investigate the IAP model in a real-world setting, teachers must be exposed to an authentic innovation. As stated earlier, an innovation is defined as "an idea, practice, or object that is perceived as new by an individual or other unit of adoption" (Rogers, 2003, p. 475) For the purposes of the present study, teachers were exposed to a software innovation called *digital annotation* as manifested in the RepliGo™ software (Cerience Corporation, 2003). While fully explained in the literature review, in this study the definition of digital annotation is derived from Smith et al.'s (2000) work with students annotating digital movies and is "the marking of a digital text during reading that explicitly connects the reader's processing of text to the text passage itself."

The Research Questions

This study, designed to engage secondary school teachers in an innovation-decision process involving a field trial of the RepliGo™ digital annotation software (Cerience Corporation, 2003), used a point-of-adoption design and deep-usage measures to gather data on their micro-adoption decisions and post-adoption outcomes to answer the following questions:

1) To what extent does diffusion of innovations theory, as embodied in the Innovation Adoption Profile (IAP), indicate the micro-adoption decisions of secondary school teachers considering participating in a four-week trial of RepliGo™ digital annotation software?
2) What do deep usage measures, as embodied in the Replacement-Amplification-Transformation (RAT) taxonomy (Hughes, 2000), describe about the post-

adoption outcomes of using RepliGo™ digital annotation software among secondary school teachers?

3) What is the relationship between teachers' IAP results and their deep usage post-adoption outcomes from the four-week trial of RepliGo™ digital annotation software?