Chapter 2

Review of the Literature

This study examines the Innovation Adoption Profile (IAP) to determine the IAP's ability to indicate teachers' micro-adoption decisions and the post-adoption outcomes of using a technological innovation called digital annotation. Second, this study describes how teachers use a digital annotation system, the innovation used in this research of the IAP. This chapter reviews the pertinent research literature and is organized into three sections. The first section reviews the literature on annotation and digital annotation systems to establish digital annotation as an innovation appropriate to this study. The second section compares and contrasts diffusion of innovation (DOI) theory with the implementation literature in the learning technology field. The third section details the criticisms of DOI research addressed by this study and illustrates these criticisms with three examples from the learning technology field.

The Literature on Annotation and Digital Annotation Systems

The historical role of annotation in learning from text. Annotation at its minimum is the marking of an existing text. A *mark* can be any visible trace and a *text* could be letters and/or symbols, audio (Coates, 2005; Northwestern University, 2005), or video (Smith, Blankinship, & Lackner, 2000). Jackson (2001), in her seminal historical examination of annotations made in books, defined annotation as marks that are "the product of an interaction between text and reader" (p. 100). She described the gamut of annotation in books and included all possible marks regardless of purpose or intent (i.e., a signature on the inside front cover, underlining, written notes). Jackson's wide-ranging

analysis also included the role annotation plays in helping readers understand what they are reading.

The practice of annotating books as an aid to the construction of meaning has been in existence for centuries. Jackson (2001) found numerous recommendations to make annotations in educational treatises and concluded annotation is "a minor theme in educational theory" (p. 48). Teachers as far back as Erasmus in the early sixteenth century "advised pupils on methods of annotation and supervised and encouraged their efforts" (p. 46). Jackson cites Pryde, author of *Highways of Literature; or, What to Read and How to Read* in 1882, saying, "Pryde promotes a system of note-taking followed by written digests in the reader's own words" (p. 49). More recently, Frederick (1938) exhorted the student to "…develop a system of marking his books so that he will quickly see *what* his thoughts were as he reads" (p. 213). Adler (1942) and Adler and Van Doren (1972) called annotation *marking* and maintained that critical reading relied on it. Finally, a form of annotation called *functional underlining* was considered by Miller (1980) "as basic to the intelligent reading of literature as a test tube is to a chemistry experiment" (p. 577). Jackson found annotating directly in books had several advantages for learners over making notes in a notebook, among them (a) the writing of annotations requires less concentration and (b) an annotation allows the passage of text in the book to be referred to later as a check against the reader's interpretation. Despite the accepted usefulness of annotation to readers' efforts to understand what they read, there are few accounts of how useful students' annotations are to their teachers.

In contemporary post-secondary institutions, where annotation is a common practice among students, instructors seldom make use of students' annotations. Salvatori

(1996) was an exception when she described how seeing a student's highlighted (equivalent to underlined) textbook altered her ideas about students' annotations:

> That class made it possible for me to turn a rather mechanical study habit—the highlighting of a text—into a strategy, one that can make visible the number and the intricacy of strands in a text's argument that a reader (or an interlocutor) pays attention to and that can show how the selection, connection, and weaving of those strands affects the structuring of the argument a reader constructs as/in response to a text (pp. 189-90).

This is a case where an instructor identified one of Jackson's (2001) advantages of annotation: the text itself served as a check against the student's interpretation. However, this was a chance, not intentional, encounter. If the student had not chosen to record her interpretation or if Salvatori's eye had not been caught by the vivid highlighting in the book open on the student's desk, then the alteration in instruction would not have occurred.

As an assessment, teachers' systematic use of students' annotations fits well with calls for literacy assessment reform. In arguing for additional assessment types, Tierney (1998) asserted that students' "learnings may be fleeting" (p. 376) and suggested teachers facilitate assessment by encouraging students "to keep traces of what they do" (p. 375). Winne and Hadwin (1998) argued specifically for teachers to examine students' margin notes as traces of their metacognitive effort, while Johnston (2003) urged teachers to notice and record the literate practices of their students. While examining students' annotations would be a step towards the implementation of these reforms, currently there are two significant barriers to the use of annotation in K-12 schools.

The first barrier to the use of annotation is the complete prohibition against marking in the textbooks students use in K-12 schools. This is for good reason as the common practice is that the school district, not the students, own the books. This barrier could be overcome by mandating that families buy textbooks for their children, or the adoption of disposable workbooks, or both. However, these solutions would leave intact the second barrier: annotations on paper materials are not easily shareable between students and their teachers. Both of these barriers are being addressed through the increasing availability of digital annotation systems.

Digital annotation systems. Digital annotation systems allow users to add marks and notes to existing digital text. In 2002, Wolfe described over 25 digital annotation systems, categorizing them as either in existence or development. While their features vary, they all overcome both of the barriers stated above by taking advantage of what Negroponte (1995) called "the differences between bits and atoms" (p. 11). Negroponte used the term *bits* to label items in the digital realm that have no physical existence (i.e., computer files such as those made by word processors, spreadsheets, and so on) and *atoms* to label anything that does have physical existence (i.e., paper, books, ink, pencil, etc.).The advantages of bits apply to all digital documents, whether they reside in a digital annotation system or not. These include (a) copies of digital documents are identical to originals and multiple copies can exist simultaneously (e.g., the original, one annotated by the student, a student-annotated version being viewed by the teacher, and one available for viewing by other teachers and parents); (b) additional information, (e.g., annotation) can be added and modified as needed; (c) digital documents can be searched with sufficient speed to make looking up a word or phrase practical; and (d) digital files

are transportable across networks of computers at the speed of light. Further, in digital annotation systems, hardware and software combine to keep all reading and annotation tools simultaneously ready for use. Readers use the same tool (i.e., a mouse, a stylus) to turn pages, browse, and add annotations. This capacity, which Marshall (1997) called "ready-to-hand" (p. 5), streamlines the making of annotations to the point where it is easier to make annotations in some digital annotation systems than it is on paper. For example, digital annotation systems, because they allow readers to manipulate bits instead of atoms, permit readers to modify their annotations after they have been made (i.e., the color of highlighted text can be changed or the highlighting deleted). Research is ongoing to upgrade digital annotation systems and explore their uses among professionals and post-secondary students.

Research into the development and uses of digital annotation systems. The research literature surveyed for this portion of the review focuses on the development and uses of digital annotation systems. Six studies (Marshall, 1997, 1998; Marshall, Price, Golovchinsky, & Schilit, 1999; Ovsiannikov, Arbib, & McNeil, 1999; Schilit, 1999; Waller, 2003) examined how adult readers annotated paper documents to inform the design of digital annotation systems. Two of these (Marshall, 1997; Ovsiannikov, Arbib, & McNeil, 1999) are reviewed here to explicate some of the ways learners use annotations.

Marshall (1997) analyzed college students' annotations by examining used textbooks selected from the stock of a college bookstore. Marshall did not have access to the students who annotated the books in her sample and thereby relied solely on the highlighted books when interpreting what she found. Marshall found that annotations

functioned as place markers and aids to memory (i.e., short passages Marshall supposed were for later use in writing a paper or preparing for a test), records of interpretive activity (i.e., marks that indicated unfamiliar language, commentary, and evidence of misreading), and visible traces of the reader's attention (i.e., more annotations were present when content seemed more difficult to comprehend).

Ovsiannikov, Arbib, and McNeill (1999) surveyed postsecondary students and professionals in neuroscience and computer science to learn how and why they annotated paper documents. Their findings included the development of a taxonomy that described their participants' uses for annotations as they were being written and/or once they had been made. These were (a) *to remember*, where readers marked the main points of the document during reading and returned to these annotations at some later point in time; (b) *to think*, where readers made these annotations during reading when they thought of new ideas, questions, and opinions; (c) *to clarify*, where readers' annotations restated difficult concepts in their own words during reading; and (d) *to share*, where readers shared their annotations collaboratively for document editing and as the basis for conversations.

Marshall (1997) and Ovsiannikov et al. (1999) identified types of annotations learners made that could be useful as formative assessments. Those identified by Marshall (i.e., highlighting a word because it was difficult, highlighting a paragraph because it was identified as important) are metacognitive traces (Winne & Hadwin, 1998). A highlighted word or phrase could signal to the teacher a difficulty a student is having, such as not being able to understand a word or being unable to distinguish what is important in a paragraph. Types of annotation identified Ovsiannikov et al. (e.g., margin

notes that document a student's questions and/or opinions) would be evidence of higher-order thinking skills.

Four studies (Lebow et al., 2004; Lick & Lebow, 2003a, 2003b; Nokelainen, Miikka, Kurhila, Floréen, & Tirri, 2005) examined uses of digital annotation systems in educational settings and indicated high levels of applicability to teaching and learning. Nokelainen et al. (2005) found that students in their university-level, web-based courses thought a digital annotation system added value to the learning process, changed their study habits favorably, and would be useful in other courses.

Lick and Lebow (2003a; , 2003b) and Lebow et al. (2004) reported on a trial of their digital annotation system, Hylighter, which "records a trace of students [sic] reading activity" (Lick & Lebow, 2003a, p. 9). The trial occurred in a community college language arts course with an instructor who had taught the same course for five years. All students in the trial were high school graduates and had successfully completed the institution's introductory English course. During the trial, the instructor used the system to give her students formative assessments. The initial assessment "exposed serious reading comprehension problems including general confusion in following relatively simple instructions" (p. 9). This first experience with the system "initiated a process that has changed the instructor's approach to teaching" (Lick & Lebow, 2003a, p. 9). At the end of the trial the instructor reported student performance as determined by grades on assignments greatly exceeded expectations, and the course completion rate was 97% compared to the typical rate of 70%.

Literacy researchers' approaches to annotation research. Literacy researchers have studied two types of annotations: underlining and/or highlighting, and margin notes

(Berger & Schlitz, 2000; Fowler & Barker, 1974; Hartley, Bartlett, & Branthwaite, 1980; Hynd, Simpson, & Chase, 1990; Lindner, Gordon, & Harris, 1996; Nist & Hogrebe, 1987; Nist & Simpson, 1988; Peterson, 1992). Participants in these eight studies were post-secondary students except those in the Hartley, Bartlett and Branthwaite study (1980), which studied sixth grade students. All studies used experimental designs, and the dependent variable in each study was student performance on a recall measure.

The literature reviews in two of the studies (Hartley, Bartlett, & Branthwaite, 1980; Nist & Simpson, 1988) surveyed a larger number of studies than the eight studies examined for this review. Hartley, Bartlett, and Branthwaite (1980) reviewed forty-one studies on the effectiveness of underlining and found that "few studies, if any, provide clear-cut support for the effectiveness of underlining, and that little is known of how children benefit (or don't benefit) from underlining" (p. 218). Nist and Simpson (1988) reviewed 13 studies that either (a) compared the effectiveness of researcher-supplied underlining with student-generated underlining or (b) compared the effectiveness of underlining with other study strategies. They found "the only safe conclusion which can be drawn is that underlining does not to appear to be detrimental" (p. 251).

Underlining was the independent variable in three of the studies, with two (Hartley, Bartlett, & Branthwaite, 1980; Nist & Hogrebe, 1987) comparing researcher-provided underlining with student-generated underlining, while the third (Peterson, 1992) compared student-generated underlining against no underlining. Hartley et al. (1980) found that sixth graders who studied materials with researcher-supplied underlining performed significantly better on a cloze test. Nist and Hogrebe (1987) found no significant difference between the treatment and control groups, and Peterson (1992)

found the control group outperformed the treatment group on an inferential recall measure.

When the independent variable was highlighting, Fowler and Barker (1974) reported no significant difference between groups of college students assigned to highlighting, underlining, or control groups. Lindner, Gordon, and Harris (1996) found no significant differences in students' performance on a multiple choice test in their first experiment, and in their second experiment, the control group outperformed the treatment group. Berger and Schlitz (2000) examined the effect of researcher-supplied underlining that was intentionally poor, comparing it to a group who received researcher-supplied highlighting that was high-quality, and a group that received no intervention. Berger and Schlitz found no significant difference between the two groups who received the intervention, and the control group outperformed both of the experimental groups.

Two studies (Hynd, Simpson, & Chase, 1990; Nist & Simpson, 1988) examined the role of margin notes in promoting recall as measured by performance on multiple-choice tests. In both studies, groups trained to make annotations in the form of margin notes outperformed either the use of self-selected study strategies or the use of a journal.

To summarize the literacy research on annotation, the primary annotation method investigated is underlining and/or highlighting, and the reason to annotate is to enhance performance on recall measures. The results indicate that, at best, the use of annotation to enhance recall produces no significant improvement. Some research does indicate recall improves when students are trained to annotate by making margin notes. However, none of the studies included in this portion of the review investigated annotation as a formative assessment. This represents a gap in how the field conceives of annotation, perhaps due

in part to the fact that the use of students' annotations as formative assessments requires teachers to have access to their students' annotations. This access is inherently impractical when annotations are made on paper materials. This study addressed that gap by placing a digital annotation system into the hands of K-12 teachers and reporting teachers' uses of their students' annotations as formative assessments.

Comparisons and Contrasts Between Diffusion of Innovation (DOI) Theory and Learning Technology Implementation Studies

Diffusion of innovation (DOI) theory is well-established, with a body of research spanning nearly sixty years and thousands of studies. This section of the review draws upon Rogers' seminal work, *Diffusion of Innovations* (2003), to represent the DOI perspective when making comparisons of DOI theory with two broad domains of learning technology research literature. These domains are the teacher-centered domain and the conditions of innovation domain. The teacher-centered domain represents a perspective where researchers focus on the teacher as the critical variable in successful technology implementations. Studies examine the characteristics of technology-using teachers and their learning processes as they seek to implement technology in their classrooms. The conditions of innovation domain attempts to define the conditions required for teachers to successfully implement technology. This comparison will illustrate that, when compared to Rogers' model of innovation decision making, these two domains leave a gap in our knowledge of how and why learning technologies are diffused in schools.

The teacher-centered domain. The teacher-centered perspective on technology implementation is represented by studies that examined how technology-using teachers differed from other teachers (Becker, 1994, 2000; Hadley & Sheingold, 1993) and studies

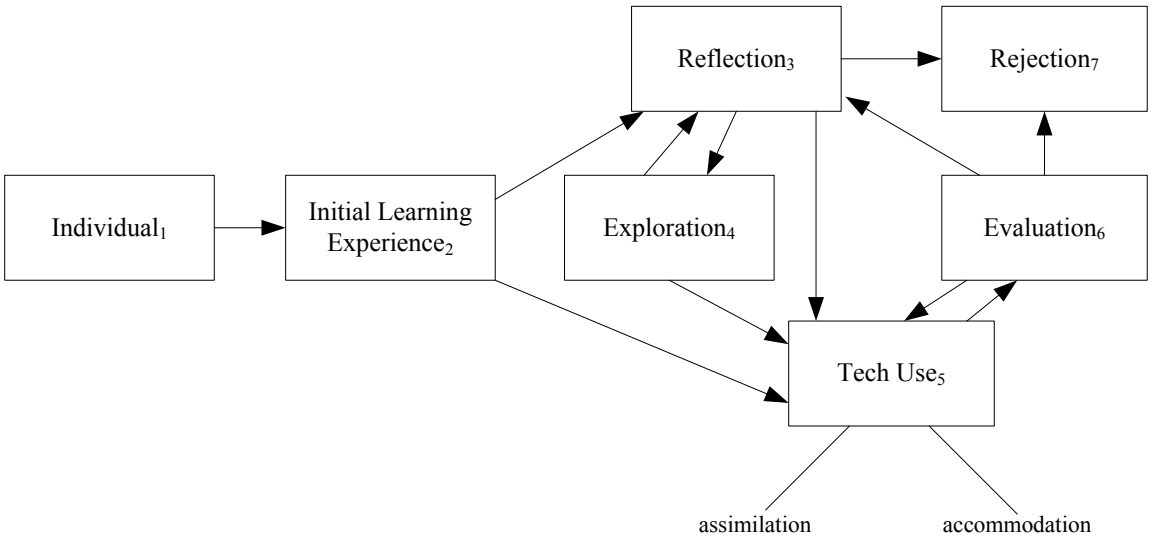
that investigated the development of technology-using teachers (Doering, Hughes, & Huffman, 2003; Hughes, 2003, 2004). Becker (1994) used national survey data to identify forty-five exemplary computer-using teachers and found that factors in the teaching environment and teachers' backgrounds were related to their exemplary-user designation. Hadley and Sheingold (1993) gathered data from a nationwide sample of 608 experienced technology-using teachers and identified three factors that contributed to these teachers' successful technology-implementation efforts: motivation and commitment, support and collegiality, and access to technology. Becker (2000) analyzed data from a nationally representative survey of teachers in grades 4-12 administered in 1998. He identified three factors in teachers' backgrounds that characterized frequent use of computers in the classroom: subject taught, level of technical expertise, and teaching philosophy. The factors identified in these studies are important, and they fit within Rogers' (2003) innovation-decision model within his prior conditions (teacher background, motivation and commitment) or factors in his first stage, knowledge (teaching environment, support and collegiality). Rogers' third stage, decision, and fourth stage, implementation, are only implied as all of these teachers had previously adopted technology and were likely already into Rogers' fifth stage, confirmation. When these studies are examined in the context of DOI theory, it becomes apparent that their contribution is limited to identifying who the adopters were. While this is important, data on Rogers' second stage, persuasion, are missing. It is in this stage that teachers form their attitudes towards the innovation, including which messages they view as credible and deciding how they will interpret those messages. This information can be gathered through the use of a point-of-adoption design, the design selected for the present study.

Studies that investigated the development of technology-using teachers (Doering, Hughes, & Huffman, 2003; Hughes, 2003, 2004) expanded the knowledge base beyond descriptions of adopters by documenting processes whereby preservice and inservice teachers moved from naïve conceptions of technology use in classrooms to more sophisticated conceptions. Doering et al. (2003) designed and taught an educational technology foundations course for preservice teachers that used a content-specific approach to technology learning. The researchers examined the students' (i.e., the preservice teachers) abilities to generate technology-supported lessons before and after the course and after a student teaching experience. Doering et al. called this ability "thinking-with-technology" and described the ultimate outcome of exercising it as being able to "choose thoughtful, challenging, and fruitful technology-supported tasks for K-12 students" (p. 343). The students had forty-nine hours of instruction over fourteen weeks, and instructor-selected technologies were presented at each class session. Doering et al. found that after the course their students could identify specific technologies presented by the course instructor that they could use in their upcoming student teaching experiences. However, after the student teaching experience, the students were unable to generate new ways of integrating technology into their lessons and instead relied on the instructor examples nearly exclusively.

Examining the study through the lens of DOI theory, the results are not surprising. The instructors were what Rogers calls the *change agents*, introducing an innovation at each class session. Each class became its own point-of-adoption setting; students implicitly moved through Rogers' innovation-decision process as shown in Figure 1. The adoption decision was the students' choice to include/not include the technologies they

learned about from their instructors in their upcoming student teaching experiences. The instructors successfully diffused several of the innovations they selected, but these were smaller innovations than what they had in mind. The innovation they were actually attempting to diffuse was not a technology in the hardware/software sense at all, but rather a new idea they called "thinking-with-technology." Doering et al. described their goal as "a paradigm shift" and noted that "honoring this shift may prove very difficult" in the time they had. This perception matches with DOI theory in that it is more difficult to diffuse an "idea-only" innovation (Rogers, 2003, p. 13) than one that includes a product.

Hughes' (2003) model of teachers' technology learning is included in this review to illustrate how DOI theory can complement teacher-centered perspectives on technology implementation in classrooms. Hughes conducted a comparative analysis across four life-history case studies of English teachers and developed a model of



teachers' technology-learning that is presented in Figure 4.

Figure 4: A Model of Teachers' Technology-Learning Phases

Note: From "Toward a model of teachers' technology learning" by J. Hughes, 2003, *Action in Teacher Education, 24*(4), p. 13. Copyright 2003 by the Association of Teacher Educators. Reprinted with permission.

This model depicts the journey teachers take when implementing technology in their classrooms. The teacher enters the model at the left as the *Individual*(1), carrying with him or her prior experiences and pre-existing knowledge of technology, content, and teaching. Similarly to Rogers' (2003) model, the individual here plays "a vital role in choosing and experiencing technology learning" (Hughes, 2003, p.13). The individual then engages in an *Initial Learning Experience* (2), which Hughes defines as "a teacher's first exposure to a new technology" (p. 13). This exposure opens multiple pathways, depending upon its effect on the teacher, which ultimately leads to either *Tech Use* (5), which Rogers would call *decision* followed by *implementation*, or *Rejection* (7), which Rogers identifies identically. In Rogers' model if rejection occurs after implementation, it is called *discontinuance*. It is important to note that Hughes' model includes two possible outcomes of Tech Use (5), *assimilation* and *accommodation*, and, while these constructs refer to what happens to teachers' knowledge, they both are compatible with Rogers' definition of adoption as "a decision to make full use of an innovation as the best course of action available" (p. 473). Hughes' model does not explicitly ground itself in time as the many arrows indicate the multiple pathways teachers can take toward either Tech Use or Rejection. However if time is added to Hughes' model, then her events and processes can be placed on a continuum, which allows for a direct comparison with Rogers' model. The two models are presented together in Figure 5 to illustrate their compatibility. Note

that Hughes' model has been modified in an attempt to incorporate a time element, thereby facilitating the comparison.

Both models show the path of an individual that ends in either Tech Use/Confirmation or Rejection. Both have advantages. Rogers' model explicates the *factors* (i.e., innovativeness, perceived characteristics of the innovation) that influence the decision to adopt or reject, while Hughes' model explicates the *processes* (i.e., reflection, exploration, evaluation) that occur during the decision making process. Hughes models *how* teachers think about technology; Rogers models *what* they think about. This study, by identifying factors teachers consider while making their technology adoption decisions (i.e., the PCIs), adds content to Hughes' model.

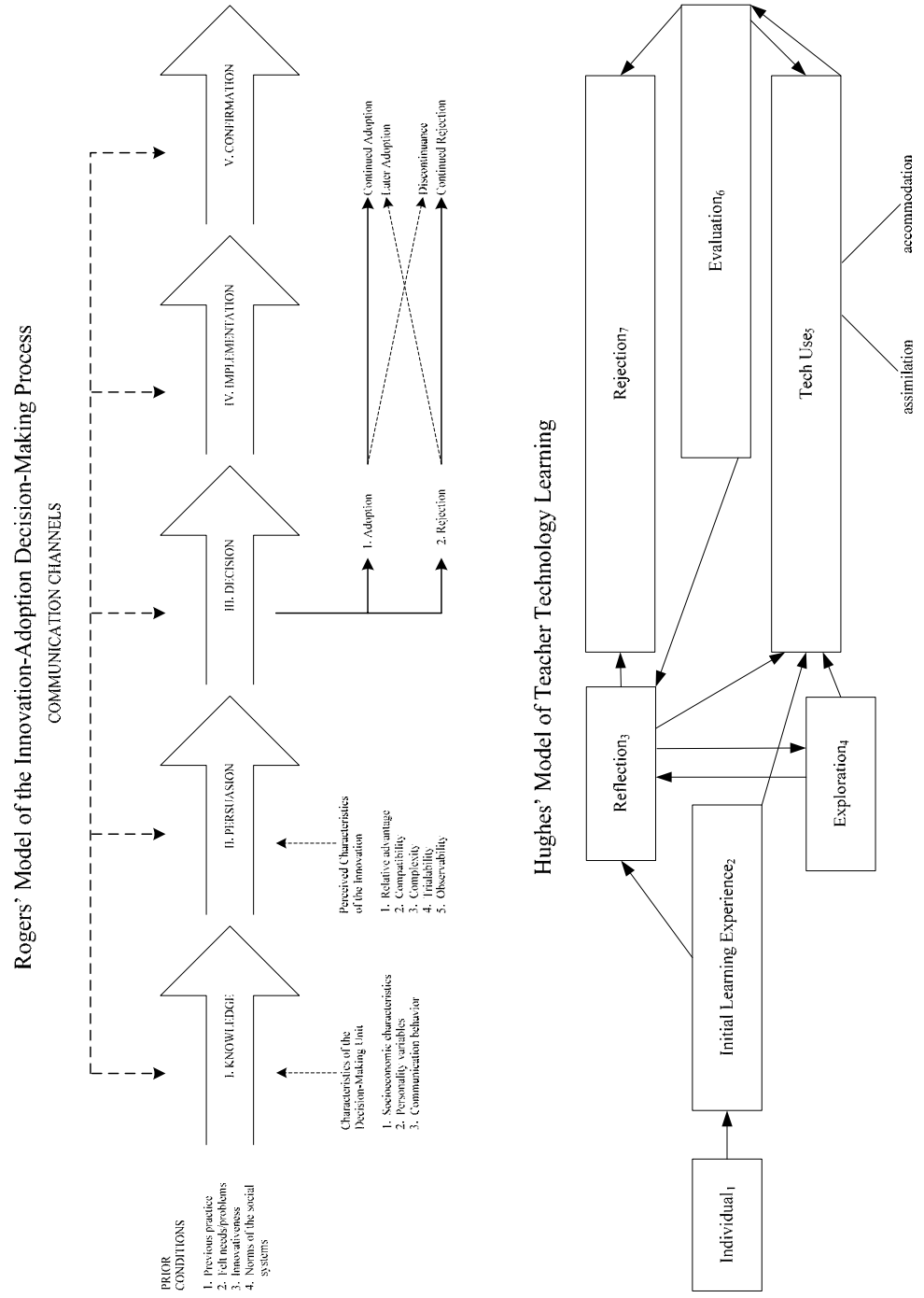


Figure 5: Comparison of Rogers (2003) model of the innovation-decision process with Hughes (2003) model of teachers' technology learning.

Note. From *Diffusion of Innovations* (p. 170) by EM. Rogers, 2003, New York: Free Press. Copyright 2003 by Free Press. Reprinted with permission. From "Toward a model of teachers' technology learning" by J. Hughes, 2003, *Action in Teacher Education, 24*(4), p. 13. Copyright 2003 by the Association of Teacher Educators. Reprinted with permission.

Studies from the conditions for innovation domain. Studies from this domain attempted to define the conditions required for teachers to successfully implement technology. Zhao, Pugh, Sheldon and Byers (2002) investigated the conditions under which technology innovations are successful in K-12 classrooms by analyzing ten case studies of teachers who were grant recipients in a statewide technology grant program. They found "11 salient factors that significantly impact the degree of success of classroom technology innovations" (p. 482). Given that each case was a teacher who had the time, motivation, and skill necessary to write a successful competitive grant proposal, it seems likely that Zhao et al. chose participants who Rogers (2003) called "innovators" or "early adopters" as their sample. These terms come from Rogers' *innovativeness* or *adopter* categories, and individuals in these categories adopt innovations much more readily than the general population. They are not representative of the population as a whole and claims based on data provided by them should be qualified. The present study took this into account by using explicit measures of individual and perceived organizational innovativeness.

Zhao and Frank (2003) attempted to answer the question, "Why is technology not used more in schools?" (p. 807). They collected frequency-of-use data on seven technologies (telephone system, voice mail, video/TV network, Internet, e-mail,

computers in school lab, and computers in classroom) from 383 teachers in 19 elementary schools and identified 20 factors that affected implementation rates. They sought to integrate these factors using an ecological metaphor based on "the introduction of the zebra mussel into the Great Lakes" (p. 807). The authors designed this metaphor because "there seems to be no framework in the existing literature that captures the dynamic nature of the technology adoption process" (p. 810). From a DOI theory perspective, this study did not define the innovation of interest: "Technology" is conceived of as a single innovation when in actuality it is many (i.e., computer, the Internet, databases, etc.). This makes identifying factors that helped or hindered diffusion very difficult. The present study addressed this by choosing a smaller, better defined innovation.

Further, Zhao and Frank conceived of "adoption" as a process, not a decision. This is a common view in the learning technology field as noted in the introduction to the present study. Most of what the learning technology literature calls *adoption* is viewed within the DOI literature as the *implementation stage* of the innovation-decision process. When implementation is investigated without attention to adoption, only a portion of the data needed to determine the responsible factors is available. The result is that less is learned about *what* occurred and *why*. The present study addresses this issue by proposing a two-stage model (i.e., teachers' adoption decision and the post-adoption outcomes of using the innovation) and a two-phase data collection design. Data are collected before teachers make their adoption decision and during the initial implementation period.

The Criticisms of Diffusion of Innovations Research

While widely accepted, diffusion of innovations (DOI) research has recently come under criticism for embracing a narrow range of research methods and measures of diffusion outcomes. Meyer (2004) noted that for nearly sixty years DOI research methodology has been dominated by an approach that relies on "quantitative data, concerning a single innovation, collected from adopters, at a single point in time, after widespread diffusion had already taken place" (p. 59). While Meyer carefully pointed out that this methodology has not produced invalid results, he stated that it "has limited what is known about the diffusion process" (p. 62). This portion of the review examines three research studies from the learning technology field (Marcinkiewicz, 1994; van Braak, 2001; Vannatta & Fordham, 2004) to illustrate the use of the dominant research DOI research methodology.

Marcinkiewicz (1994) analyzed the relationship among seven factors (innovativeness, teacher locus of control, perceived relevance of computers to teaching, self-confidence, age, gender, and years of computer experience) and the level of computer use among elementary school teachers (N=170). Although interested in the predictiveness of these factors, Marcinkiewicz acknowledged that computers had already diffused through the schools of participating teachers when the study began. This fits Rogers' description of postdiction and reduces the ability to understand what happened *during* the diffusion. The outcome of the diffusion, computer use, was reported as one of three levels ("nonuse" "utilization" or "integration") for each teacher and does not indicate the *ways* computers were used in their classrooms.

van Braak (2001) examined the power of eight factors (age, gender, teaching subject, computer experience, attitudes toward the Internet, individual innovativeness,

perceptions of the Internet, and organizational constraints) to predict the use of computer-mediated communications (CMC) among 357 secondary school teachers in Brussels, Belgium. In contrast to the postdiction problem encountered by Marcinkiewicz (1994), van Braak reports that only one in five teachers was actually familiar with CMC prior to the study and did not report on efforts to acquaint the others. So instead of gathering perception data after CMC had been adopted, van Braak was confronted with the difficulty of making predictions based in part on perception data from individuals who had no familiarity with CMC. The outcome of the diffusion of the innovation, CMC use, in this study was described as "mainly used for accessing electronic mail, and access to electronic information and downloading software without integrating CMC into the classroom" (p. 46). No information on *how* teachers used CMC was reported.

Vannatta and Fordham (2004) measured ten factors (teaching self-efficacy, locus of instruction, constructivism, openness to change, willingness to take graduate courses without salary incentive, professional development hours in past two years, technology training hours in past two years, hours typically worked beyond contract, years of teaching, and gender) as predictors of teachers' (N=177) classroom technology use. While not explicitly grounded in DOI theory, the study approached the problem using the dominate DOI methodology. The postdiction problem appeared as the study relied on adopters to provide data after the diffusion of the various classroom technologies was completed. The "shallow usage" (Chin & Marcolin, 2001) problem (i.e., use vs. non-use, frequency and/or duration of use) is apparent in the outcomes described in the study. The Faculty Technology Survey (Vannatta & O'Bannon, 2002) was used to gather information about teachers' classroom technology use, and the instrument only gathered

frequency data. From this study we know *what* technology is being used and *how often* it is used in these classrooms, but we do not know anything about *why* it was adopted or the *ways* it was being used.

In order for the knowledge base of DOI research to expand beyond the methodological bind illustrated here (i.e., reliance on postdiction, large-scale quantitative measures, and shallow usage measures), we must respond to the twin calls to innovate issued by Meyer (2004) and Chin and Marcolin (2001). Meyer provided specific suggestions for how to expand DOI methodology beyond the dominant paradigm, and this study incorporates two of those suggestions by using (a) a point-of-adoption design where "data is [sic] gathered from respondents at the time they adopt the innovation rather than at some point in the future" (p. 64) combined with (b) the integration of qualitative methods that "may serve as a validation tool when considered along with data collected through quantitative methods" to increase the "understanding of what happened over the course of the diffusion process" (p. 68). In addition, this study incorporates Meyer's advice to look at adoption longitudinally rather than merely at a single point in time by developing two case studies of teachers who adopted the RepliGo™ digital annotation software. This design also responds to Chin and Marcolin's call for DOI researchers in information systems to stop using "shallow usage" (p. 9) measures and adopt constructs of usage that are "tightly coupled to the actual act of technological use" (p. 10). This is accomplished through the adoption of Hughes' (2000) Replacement/Amplification/Transformation framework for the case study data collection and analysis.