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Understanding Technology Adoption: Theory and Future Directions for Informal Learning

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How and why individuals adopt innovations has motivated a great deal of research. This article examines individuals' computing adoption processes through the lenses of three adoption theories: Rogers's innovation diffusion theory, the Concerns-Based Adoption Model, the Technology Acceptance Model, and the United Theory of Acceptance and Use of Technology. Incorporating all three models, this article suggests technology adoption is a complex, inherently social, developmental process; individuals construct unique yet malleable perceptions of technology that influence their adoption decisions. Thus, successfully facilitating technology adoption must address cognitive, emotional, and contextual concerns. This article also focuses specific attention on adoption theory outside of a formal organization and the implications of adoption theory on informal environments.

KEYWORDS: technology adoption, teacher education, social cognitive theory.

For a crime against the gods—the specifics of which are variously reported—he was condemned to an eternity at hard labor. And frustrating labor at that. For his assignment was to roll a great boulder to the top of a hill. Only every time Sisyphus, by the greatest of exertion and toil, attained the summit, the darn thing rolled back down again.

—The Encyclopedia of Greek Mythology (n.d., para. 4)

Introduction

This decision of whether an individual will adopt a particular technology and the time frame involved with that decision has been a long source of research across multiple disciplines, and it influences business, school, and everyday life. However, the concept of technology literacy is increasingly becoming integrated into mandated curricula (Barron, Kemker, Harmes, & Kalaydijian, 2003), forcing some level of technology adoption on many school districts and teachers. Although decisions about integration of technology are frequently at a higher level, such as a school or district level, it is the individuals' adoption patterns that illustrate a successful implementation. Therefore, it is essential to understand such aspects of the process such as the following: Why does one individual choose to adopt a technology while another resists? What is the influence of social context on the decision to adopt? These questions are addressed in the context of adoption and diffusion theories.

This article describes several key innovation adoption and diffusion theories by examining its theoretical base, key components, and strengths and weaknesses. Ultimately, the question this article seeks to understand is this: Can any one of these theories (or a combination of theories) bring meaning and understanding to why an individual chooses to adopt or reject a particular innovation (and in particular a technology-based innovation)? This review then suggests three conclusions about technology adoption and diffusion theories: (a) technology adoption is a complex, inherently social, developmental process; (b) individuals construct unique (but malleable) perceptions of technology that influence the adoption process; and (c) successfully facilitating a technology adoption needs to address cognitive, emotional, and contextual concerns. Finally, this article considers these perspectives on innovation adoption and diffusion in terms of the gaps in the literature: What are the possible effects of the continuous cycle of adoption in today's society, how one understands the basic adoption construct of usefulness, and what do people know about technology adoption outside of the formal organization?

Defining Innovation

Before one can examine how a particular innovation disperses and distributes within a population, one needs to operationalize what is meant by the term *innovation*. At the broadest sense, an innovation can be any new idea to a population. Rogers (1995) defined an *innovation* as "an idea, practice or object that is perceived as new by an individual or other unit of adoption" (p. 11). It does not matter if the idea, practice, or object is objectively new; rather, it is the perception of novelty. In addition, innovation also does not necessarily mean better or that the new idea is more beneficial to an individual. Whereas innovation can refer to something abstract, like an idea, it can also be concrete, like a new piece of technology. This article focuses specifically on computer-based technologies as a particular type of innovation of interest.

What Are Adoption and Diffusion Theories?

Adoption theory examines the individual and the choices an individual makes to accept or reject a particular innovation. In some models, adoption is not only the choice to accept an innovation but also the extent to which that innovation is integrated into the appropriate context. Adoption theory, then, is a microperspective on change, focusing not on the whole but rather the pieces that make up the whole. In contrast, diffusion theory describes how an innovation spreads through a population. It may consider factors like time and social pressures to explain the process of how a population adopts, adapts to, or rejects a particular innovation. Diffusion theory takes a macroperspective on the spread of an innovation across time. In Figure 1 is a representation of a diffusion curve, which is a graphical representation of cumulative frequency of individual adoptions. It illustrates how the diffusion over time is composed of individuals making adoption decisions.

Adoption and Diffusion Models

There is no one model for understanding the processes in which an individual engages before adopting a new innovation. Historically, adoption is understood in terms of some kind of behavior change. Adoption and diffusion of new health behaviors, like smoking cessation or weight loss programs, have been studied in

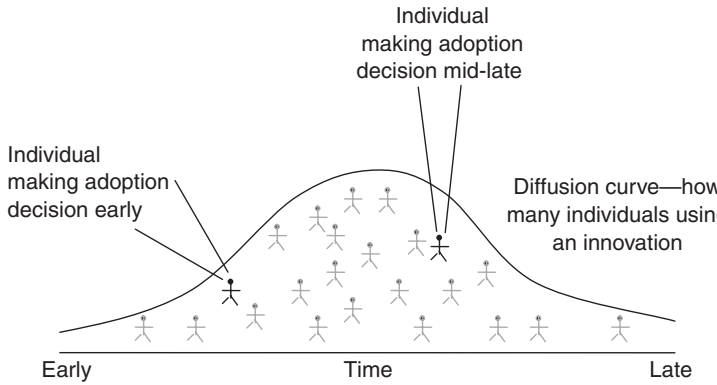

FIGURE 1. How individual adoptions compose diffusion.

the medical and healthcare fields (for a review of several health-based behavioral adoptions, see the Evidence Based Work-Group, 2005). Additional models have come out of sociology (Deffuant, Huet, & Amblard, 2005; Rogers, 1995), education (Hall & Loucks, 1978; Pennington, 2004), and computer science (Venkatesh, Morris, Davis, & Davis, 2003). Whereas the results of adoption theory are measured in terms of behavioral change, the predictors of that behavioral change can be understood through contextual, cognitive, and affective factors. Existing theories deal independently with these factors but no one theory accounts for all three.

This article discusses three adoption and diffusion theories selected based on the prevalence of appearance in the literature. First, Rogers's theory of innovation diffusion provides a foundational understanding of adoption theories. Rogers's theory has been used broadly across disciplines to comprehend and predict change. Although Rogers's theory is a critical foundation, it is not always easily applied to understanding adoption. Although several research studies seek to understand adoption process, only a few theories are widely used in the current literature. A review of the research in education revealed two primary theories of adoption applied in the current education literature. First, the Concerns-Based Adoption Model (CBAM) has been used to understand change in terms of technology. The CBAM has been used to understand teacher change in curriculum change (Christou, Eliophotou-Menon, & Phillippou, 2004) and adoption of a consulting teacher model (Pedron & Evans, 1990) as well as specifically technology change and adoption (N. E. Davis & Roblyer, 2005; Dobbs, 2004). In contrast, the Technology Acceptance Model (TAM) and the Universal Technology Adoption and Use Theory (UTAUT) are originally based out of computer science specifically to answer questions about technology adoption. They have also been applied to many educational settings including understanding adoption by student teachers (Ma, Andersson, & Streith, 2005), implementation of laptop-based testing (Baker-Eveleth, Eveleth, O'Neill, & Stone, 2007), and adoption of online learning (Ndubisi, 2006). Finally, throughout this article, both adoption and diffusion theories are referred to collectively as *adoption-diffusion theory* because the individual differentiation of the two is beyond the scope of this article.

Shared Views in Adoption and Diffusion Theories

Before addressing any individual theory of adoption or diffusion, there are some commonalities across diffusion theories that should be addressed. This section of the article addresses some of the assumptions and biases of adoption-diffusion theory as well as present social cognitive theory as a lens influencing all adoption-diffusion theories.

Although adoption and diffusion theories address different aspects of behavioral changes, most do share certain commonalities and assumptions. Most believe that the adoption process is not a single event. Whereas the decision to or not to adopt an innovation can be a one-time event, the route that leads to one's decision does not take place in a vacuum. Beliefs and attitudes are formed over time, which in turn may influence decisions.

The implicit bias of adoption-diffusion theories. Before pursuing any particular diffusion-adoption theory, one must recognize that all of the theories discussed in this article have an implicit proadoption bias. These theories all assume that the goal is to disseminate information about a particular innovation specifically for adoption. In fact, when adoption does not occur, it is considered a failure of the diffusion-adoption process, or nondiffusion (Rogers, 1995) rather than its own stage of a process.

Categories of change theories characteristics. Although adoption and diffusion theories have different scopes and different perspectives on the change process, a closer examination of their characteristics shows that most theories share three categories of characteristics that influence the adoption and/or diffusion of an innovation. Individual characteristics are individual differences—state- or trait-based characteristics that predispose a person to seek out or shun change. For example, some research suggests that there may be personality traits that predispose certain people to adopt innovations and/or adopt them more quickly than others (Agarwal & Prasad, 1998b; Wood & Swait, 2002). Innovation characteristics are specific to the particular innovation—how easy an innovation is to use, how the use of an innovation is compatible with the lifestyle of an individual. Lastly, contextual characteristics make up the environment and surroundings of an individual during the adoption process—frequently this is the work-based organization, but it also may be the mass media or individuals acting as facilitators of change.

Social Cognitive Theory as a Lens for Adoption and Diffusion Theories

Social cognitive theory (Bandura, 1997) is one of the most influential theories in psychology and education today. Although social cognitive theory was developed after some of the initial foundations of these theories, modern versions of the models presented here are influenced by social cognitive theory either explicitly or indirectly. Because of its importance, this article shall discuss a few of the overarching foundational beliefs of social cognitive theory that influence adoption and diffusion theories. The concepts of social learning and self-efficacy will be acknowledged as components of the models discussed later in this article. Not all constructs are within the scope of this article, but I would like to acknowledge that there are many more aspects of social cognitive theory that are applicable to understanding change and adoption, including attitude and belief development, self-regulation, and affect.

Social learning. Individuals are capable of learning not just from their own experiences but from the experiences of those around them (Bandura, 1986). The ability for a human to learn vicariously (by observation of others rather than by their own experience) is one of the foundational concepts of social cognitive theory. The observational learning processes are regulated by four subfunctions—attentional processes (is this behavior important and accessible to me?), retention processes (is it salient enough to remember?), production processes (can I reproduce the action?), and motivational processes (am I encouraged to do this again?) (Bandura, 2001).

In terms of adoption and diffusion, social learning has two potential roles. First, through modeling, individuals observing others adopting a particular innovation may be more inclined to consider adoption themselves. The vicarious experience of someone successfully or unsuccessfully using a technology may influence others. Secondly, in previous years, modeling was primarily conceptualized as a concrete phenomenon, but the technological developments of recent years and the accessibility of mass media, modeling, and vicarious learning suggest that vicarious learning also occurs in the symbolic realm (Bandura, 2001). Not only does social learning influence the decision whether to adopt a technology but the explosion of the Internet, widespread use of television and radio, and even the influx of cellular phones has expanded the space to a worldwide area of possibilities.

Self-efficacy. Self-efficacy refers to the "beliefs in one's capabilities to organize and execute the courses of action required to produce given attainments" (Bandura, 1997, p. 3). Self-efficacy is always forward thinking about judgments based on beliefs about personal capability. It is not to be confused with self-esteem or self-confidence, two related but different concepts. Whereas self-esteem and self-confidence deal with a more holistic view of one's capabilities, perceived self-efficacy is an individual's belief that he or she can complete a specific task given a set of circumstances.

Bandura (1997) contended that the development of self-efficacy is informed by the following factors: mastery experiences, vicarious experiences, verbal persuasion, and psychological and affective states. In terms of adoption, the judgments individuals make about their capability for completing technology tasks have been linked to computer attitudes which are in turn linked to future technology use (Compeau, Higgins, & Huff, 1999)

Summary

Adoption-diffusion theories refer to the process involving the spread of a new idea over time. The adoption process refers to the individual's decision whether to integrate an innovation into his or her life; diffusion describes a collective adoption process over time. Adoption-diffusion theories share several characteristics and, for the purposes of this article, are argued to be viewed through a social-cognitive lens.

Rogers's Innovation Diffusion Theory

Everett Rogers's 1962 work, *The Diffusion of Innovations* (and subsequently, the numerous later editions), has become arguably the most influential book in the area of understanding how an innovation infiltrates a population (or not). Drawing on a wide range of research crossing fields of sociology, education, psychology,

geography, and others (Rogers, 1995), Rogers provided a comprehensive structure for understanding individual adoption and, collectively, diffusion. Rogers's theory is particularly important because it has influenced numerous other theories of adoption and diffusion (Boyne, Gould-Williams, Law, & Walker, 2005; Deffuant et al., 2005; Pennington, 2004; Venkatesh et al., 2003).

The strength of Rogers's theory is in the broad foundation it provides to understand the factors that influence the choices an individual makes about an innovation. It is the basis for understanding adoption. Because of the magnitude of this theory, this section can only begin to touch on the various components, but it provides a basic understanding of the innovation diffusion theory (IDT).

Adoption as a Subprocess of Diffusion

In IDT, the adoption process is inseparable from the diffusion process. Diffusion is composed of individual adoptions. Diffusion describes the adoption process across a population over time. As such, in this article, adoption is discussed in terms of its role within diffusion theory.

The adoption decision process describes five stages that individuals go through during their evaluation of an innovation. Stage one is when an individual becomes aware of an innovation. The awareness of an innovation is influenced by personal characteristics (it is hypothesized that there is a personality trait that promotes change seeking in individuals; Wood & Swait, 2002), socioeconomic factors, and access to change agents like mass media (Bandura, 2001). Stage two, persuasion, is when an individual gains enough knowledge about the innovation's salient characteristics (further discussed later in this section) to make a personal judgment, the outcome of which is a favorable or unfavorable view of the innovation. Stage three, decision, has an outcome of an individual's choosing to adopt or reject an innovation. Stage four, implementation, is when an individual acts on his or her decision. Finally, in stage five, confirmation, an individual reflects on his or her decision and implementation process and re-evaluates whether to continue or discontinue with the innovation adoption (Rogers, 1995).

IDT—Key Components

Rogers defined diffusion as a "special form of communication" (1995, p. 5) where new ideas are spread from individual to individual over time. First, the Innovation-Decision process describes a model for how an individual makes a choice to adopt or reject a technology. Next, the four primary components of diffusion theory are discussed: (a) the innovation itself, (b) communication channels, (c) social system, and (d) time. The four elements interact to describe how individual adoptions combine to represent diffusion. In the following sections, this article examines the individual key elements as framed through both individual adoption and the larger, collective diffusion of the innovation.

The innovation. Rogers identified five attributes of an innovation that influence its adoption: relative advantage, compatibility, complexity, trialability, and observability. First, the relative advantage of an innovation is the perception of an individual that the innovation will be better or worse than similar ideas. Those innovations that are perceived to be better will be adopted more rapidly than others will. Compatibility is the perception that a particular innovation is similar and

congruent with existing understandings of similar and past ideas. Innovations that fit into an individual's existing understanding or schema will be more easily adopted. Complexity refers to the perception of how difficult to comprehend an innovation is, and it is hypothesized to be negatively related to the rate of adoption of an innovation (Rogers, 1995). Trialability refers to the accessibility of an innovation to an individual for experimentation. Electronics stores encourage trialability by displaying video games for people to play while shopping—the opportunity to try out an innovation will facilitate the adoption of an innovation. Trialability can be direct or vicarious. Finally, observability is characterized by how available and visible an innovation is to an individual. The idea behind observability is similar to unspoken peer pressure—if everyone else has an innovation, an individual will be more likely to adopt it as well. Observability leads to a social threshold—the point when an innovation becomes so pervasive in a culture that even those who would not normally adopt consider adoption of an innovation.

Communication channels. Communication channels are the means and mechanisms by which information about a particular innovation is passed from individual to individual. This can be direct communication, vicarious observations of peers and models, or even the influence of mass media (Bandura, 2001; Rogers, 1995). The level of access an individual has to innovation affects the diffusion process. Interpersonal communications, like subjective evaluations of an innovation by a peer or exposure through mass media of what Rogers calls "near-peers" can influence an individual to adopt a similar perspective on an innovation (Rogers, 1995). This communication process is essential for diffusion—if the idea does not spread from person to person, it will not circulate in a population.

Social system. The social system in IDT refers to the context, culture, and environment that an individual is involved in. Rogers (1995) defined it as "a set of interrelated units that are engaged in joint problem-solving to accomplish a common goal" (p. 23). As a broad definition, social systems could be work environments, organizational groups, informal group, and all the various subsystems of any of these groups. Social norms and structure influence and affect how an innovation infiltrates a population.

Time. Rogers's work on adoption and diffusion is framed through the context of time. What makes one individual adopt a particular innovation early versus late? What characteristics and influences are salient to an early adopter versus a late adopter? To better understand this process, Rogers first categorized adopters into groups based on the relative amount of time it took for a percentage of individuals to adopt. This diffusion curve (generally conceptualized as an S shape or a normal curve) suggests that there is a small percentage of early adopters, a large group of mainstream adopters (early and late majority), and finally a small percentage of late adopters. By grouping these individuals, commonalities in personality, socioeconomic situations, and communication behaviors emerged. Early adopters tend to have higher socioeconomic status, have broad access to communication methods, have higher upward mobility within their social culture, are more likely to be literate, tend to be more intelligent, and have higher capacity for uncertainty for change.

IDT: Concerns, Critiques, and Future Research

Rogers's IDT theory provided the fundamental groundwork synthesis of adoption-diffusion literature across disciplines. His theory is still actively used in the research either directly or implicitly through its influence and integration into other theories. Rogers's theory has influenced other research of adoption and diffusion (Boyne et al., 2005; Deffuant et al., 2005; Pennington, 2004; Venkatesh et al., 2003).

Although I could not find anything directly disputing IDT, it is not without some concerns. IDT provides a framework, but the breadth and depth of the theory makes it difficult to frame a single study within the structure. In addition, as it is primarily descriptive rather than prescriptive, it does not tell how to facilitate adoption but rather why adoption occurs. Because it can be applied to any discipline, a specific implementation of the model may require some tweaking to suit the individual situation.

One benefit to IDT, however, is the framework is flexible enough to fit both a formal and informal adoption environment. Much of the research on diffusion takes place in informal environments—agriculture adoptions, consumer behavior (Rogers, 1995)—suggesting that the framework developed by Rogers would apply beyond the walls of an institution or corporation. Most other adoption theories (as presented later in this article) focus specifically around the directed implementation of an innovation.

Hall's CBAM

Rogers's IDT is probably the most influential theory in the research. However, it does not apply practically to all situations. This section of the article addresses why the academic environment was in need of a different adoption model than what may be used in a corporate setting. The CBAM provides a different perspective on facilitating adoption. By approaching adoption through the eyes of the adoptees, the CBAM provides a developmental perspective on how an individual's concerns influence his or her integration of an innovation.

The strengths of the CBAM are in this application of cognitive concerns through the context of an educational setting. By addressing the concerns of teachers from a developmental perspective, it can provide administrators with an idea of how teachers will adapt to change and provide a framework to anticipate future needs. This section discusses the primary characteristics, limitations, and contributions of the CBAM.

Foundations for the CBAM Educational and Teacher Change: Why a Teacher-Specific Model?

The academic and university setting is an ancient venue. Universities have been present and active in society for thousands of years. Although the job description of teacher and professor has changed since the day of Plato and Aristotle, academic institutions are not as influenced by the context of time. Educational practices change slowly. Meyer and Rowan (1977; as discussed in Jaffee, 1998) described the idea of rationalized myths—that certain organizational practices are continued because of tradition and a shared organizational value rather than empirically verified value. Indeed, the core tools of classroom teaching have varied little in the

past 100 years (Cuban, 1983). Although teacher change is not a specific decision-making theory for teachers, it is an important foundation for this model. A full discussion of teacher change is out of the scope of this article, but addressing teacher change as the impetus for the development of this model is warranted.

The role of the teacher is ingrained with a long-standing history and tradition of the profession. Teachers and professors are considered the expert in their classroom with students attending to learn from their expertise. This identity of teacher is cyclical coconstruction between student and teacher—children become students learning through their instructors' modeling what the idea of *teacher* embodies. As these children grow and become the future teachers, their conceptualization of teacher becomes intertwined with this history (Flores & Day, 2006). Jaffee (1998) hypothesized that "the greater degree to which a particular organizational practice defines and reinforces one's core professional identity, the greater the opposition and resistance to alternative practices and routines" (p. 27). These deep-seated beliefs and identity structures can lead to resistance to change and to acceptance of innovation.

Even with the long history of nonchange, educational institutions are still influenced by societal changes and external pressures (albeit more slowly). Educational reform in this country developed national standards for teaching and teacher skills. These standards now provide stipulations and regulations for what should be required from teachers, leading to increased pressures for teachers to continue professional development to meet these standards. New practices go against the historically understood definition of teacher. Lecture format and teacher-directed instruction is beginning to give way to more student-centered classrooms. Instructional technology has become a necessary component of a teacher skill set. The cognitive dissonance and affective results of these changes are the impetus for the development of a model directly addressing the unique needs of teachers going through a change. Facilitating these external, top-down changes is the basis for Hall's CBAM.

CBAM—Assumptions and Key Concepts

The CBAM was developed by Hall, based on Fuller's work in teacher change and classification of teachers' concerns from a developmental perspective (Christou et al., 2004; Fuller, 1969; Hall, 1979). The goal of the CBAM was "to ease the problems diagnosing group and individual needs during the [innovation] adoption process" (Hall & Loucks, 1978, p. 36) so that change and innovation would be more easily facilitated. The CBAM has been used in a variety of different settings, from the K-12 environment (Christensen, Griffen, & Knezek, 2001) to other education-based professions (Bailey & Palsha, 1992) and across cultures (Cheung & Yip, 2004; Christou et al., 2004). By addressing affective and cognitive concerns of teachers, the CBAM can ease the change process.

The CBAM was developed based on six explicit assumptions:

> Change is a process, not an event.
> Change is accomplished by individuals.
> Change is a highly personal experience.
> Change involves developmental growth.
> Change is best understood in operational terms.
> The focus of facilitation should be on individuals, innovations, and context.
> (Hord, Rutherford, Huling-Austin, & Hall, 1987)

These assumptions form the basis of the three components of the concerns-based model: stages of concern (SoC), levels of use (LoU), and innovation configuration (IC).

Designed as a diagnostic but not prescriptive tool, the three components help inform the change facilitator as to how to best facilitate the adoption of an innovation. Because it focuses on the facilitation of change, CBAM does not describe the whys of innovation adoption but, rather, how understanding concerns of a population can facilitate innovation adoption.

Individual characteristics—SoC. The SoC describe the concerns teachers have as they progress through the adoption process. At the beginning stages, concerns revolve around personal issues and, as those concerns are met, they evolve into concerns about their students and implementation. It represents a "possible, not a necessary developmental progression" (S. E. Anderson, 1997). The levels are not mutually exclusive—teachers will evidence concerns of all stages at any given point during the process. In fact, many teachers will not reach the highest SoC. It is also not hierarchical, and when a teacher moves out of one stage, they still may have concerns consistent with previous stages.

Concerns are broken down into the stages presented in Table 1. (Because this model was specifically developed for teachers, this article will continue to refer to the CBAM in reference to the teaching profession, although it could be used outside of academic settings.)

Innovation characteristics—LoU and IC. The CBAM also describes the behavioral diffusion of an innovation through the LoU scale. Whereas the SoC describe attitudes and concerns, the LoU provide a framework for understanding the behavioral implementation of an innovation. The LoU break down the actions of teachers into categories from nonuse at the lowest behavioral implementation to renewal, the highest, indicating a teacher transforming and extending the innovation.

The use of CBAM. In practice, the SoC are used most frequently in the research literature to describe teacher change. A teacher's SoC can be assessed through quantitative measures (a survey) or qualitative interviews. The change facilitator then interprets the results to develop profiles of various teachers. Although single peak profiles (profiles with teachers peaking in one category of concerns) were considered common in Stages 3–6 (stages associated most commonly with the actual implementation of an innovation; Hord et al., 1987), later research suggests that clear-cut profiles may not be the norm (Bitan-Friedlander, Dreyfus, & Milgrom, 2004).

In a study by Christou et al. (2004), the SoC survey was administered to 655 teachers at more than 100 elementary schools in Cyprus during the implementation of a new mathematics curriculum. Teachers with various years of involvement with the curriculum as well as varying years of teaching experience were included. Stage 1 of the SoC was eliminated because all participants were aware of the curriculum changes. In opposition to Hall's theory, the teacher's concerns did not vary according to years of experience with the innovation nor through the implementation progression. Similarly, experience with a new teaching method alone was not enough to motivate teachers to progress developmentally (Cheung & Yip, 2004). These findings imply the construct of the stages may still need some enhancement.

TABLE 1
Stages and descriptions of the stages of concern

Stage	*Name*	*Description of concerns*
0	Awareness	Teachers have little awareness or concern for a particular innovation. The innovation is seen not to affect them at this stage.
1	Informational	Teachers have general or vague awareness of an innovation. Teachers may begin some information seeking to gain additional knowledge about the innovation.
2	Personal	Teachers' concerns are about the personal costs of implementing an innovation—how a particular innovation will change the demands of or conflict with existing understanding of what they currently do.
3	Management	Teachers' concerns will focus around how to integrate the logistics of a particular innovation into their daily jobs.
4	Consequence	Teachers' concerns are primarily on the impact of the innovation on their students.
5	Collaboration	Teachers begin to have concerns about how they compare to their peers and how they can work with their fellow teachers on an innovation.
6	Refocusing	Teachers' concerns are how to better implement an innovation.

Sources: S. E. Anderson, 1997; Hall, 1979; Hord, Rutherford, Huling-Austin, & Hall, 1987.

CBAM: Concerns, Critiques, and Further Research

Although the CBAM has been used for many years as a productive tool for facilitating change in educational settings, it is not without criticism. This section addresses some of the published literature regarding concerns about the CBAM as well as some other possible further applications of the CBAM.

SoC—reliability and validity. Although the SoC may be useful to broadly diagnose potential problems in a change population, there are still inconsistencies in results (Bitan-Friedlander et al., 2004; Christou et al., 2004). In their studies, Bailey and Palsha (1992) suggested that the SoC scale had substantial reliability issues in two of the stages, the awareness stage and the refocusing stage, and suggested reorganizing the SoC into a 5-stage model (Awareness, Personal, Management, Impact, and Collaboration), along with a shorter version of the SoC survey. Further research has shown that the 5-stage model increases reliability of the stages, but the shorter version of the survey suggested by Bailey and Palsha lacks the desired validity scores (Schotsberger & Crawford, 1996). Clearly, additional research into the reliability and validity of the scale is needed.

End-user of innovation—teacher or student? The consumer in the CBAM is the teacher who is preparing to implement a particular technology (Hord et al., 1987).

TABLE 2
Stages and descriptions of levels of use

Level	*Name*	*Description of use*
0	Nonuse	A teacher does not use or has no intentions to use an innovation.
1	Orientation	A teacher is seeking additional information about an innovation but has not determined whether he or she will implement it.
2	Preparation	A teacher gets ready to include an innovation (but has not yet implemented it).
3	Mechanical	A teacher begins implementation but generally struggles with logistics of the innovation.
4A	Routine	A teacher successfully integrates an innovation.
4B	Refinement	A teacher changes the innovation to suit his or her needs.
5	Integration	A teacher goes beyond his or her own classroom to share his or her implementation of an innovation with peers.
6	Renewal	A teacher extends an innovation, transforming the innovation.

Source: Anderson, 1997.

The CBAM generally approaches change as a mandate from an administrator or other leader position then diffused to the teachers as the ultimate consumer of the innovation. However, the CBAM pays relatively little attention to the student in the model other than in the Consequences stage of teachers' concerns. Although the teacher may be the initial recipient of a change, this change also filters down to the students. The teacher is not only an adopter of the innovation but also must act as a change agent for his or her students. As student-centered pedagogy becomes more widespread in the education system, the effect of the students in this model may become more critical. Further research into the students' role in the CBAM could prove to be an interesting moderator of behavior.

Limitations of a concerns-based model. Although a concerns-based model may be helpful to a facilitator implementing an innovation, it is limited because of its disregard of teachers' positive perceptions of an innovation. Teachers may have resistance to change but they also may have some positive positions on a particular innovation that may coincide with the existence of the concerns. By ignoring teachers' possible preferences for an innovation, this model sells teachers short by portraying them as resistant luddites. In addition, the CBAM admittedly primarily deals with top-down change (Hord et al., 1987). How preferences for an innovation implementation interact with concerns for a particular implementation is an issue for future research as well.

Informal methods of adoption facilitation. The CBAM claims to be a client-centered model (Hord et al., 1987). Yet the model is heavily focused on the change facilitator to move change along. In the later stages of the CBAM, teacher concerns address working collaboratively with other teachers, moving away from the

personal concerns. One possible extension of the CBAM is to try to address collaborative work with teachers earlier in the model rather than just through a specific change agent. It has been suggested that making teachers responsible for each other's professional development (in conjunction with change facilitators) may be an effective form of teacher development (Glazer & Hannafin, 2006; Wolski & Jackson, 1999). An area for future research would be to explore how the concerns-based model could be implemented in more informal facilitation structures, like a community of practice model (Wenger, 1998).

Summary and Implications

The CBAM has been widely applied in education settings to facilitate teacher change. Assuming that the population is inherently resistant to change, the CBAM is extremely beneficial in assisting an organization in facilitating implementation of an innovation by addressing the affective and cognitive concerns of teachers. The CBAM challenges administrators to look beyond their own beliefs about the possible benefit of an innovation and to examine the implications of that change on those it affects most. Top-down mandated change may be quick to proclaim the benefits of a change without understanding the deeper affective variables that may be shifted with any change.

Technology Acceptance Model and the United Theory of Acceptance and Use of Technology

In contrast to the previous models discussed, which dealt with a specific type of adoption environment, the next model deals with a specific type of innovation. Although many models of innovation adoption include any new idea as the concept of an innovation, the need for organizations to integrate computer-based information technologies has evolved into its own subset of adoption research. The increased presence and relatively short life cycle of any given specific technology means that corporations, educational institutions, and others are required to implement broad-reaching programs to encourage (and eventually mandate) information technology use.

Numerous theories have arisen, particularly out of the information sciences literature, trying specifically to predict computer use through personal factors. Venkatesh and colleagues (2003) presented a comprehensive review and history of the various theories used to predict computer use in the past few decades. These are primarily quantitative theories used to inform organizations about who will adopt an innovation most quickly; however, most of the individual theories are criticized as being fragmented, lacking a cohesive model that accounts for the numerous factors that influence technology use (Venkatesh et al., 2003).

The TAM and UTAUT excel in the easy applicability of the theory. The TAM has been used in many educational settings to explain acceptance (Baker-Eveleth et al., 2007; Cheng-Chang, Gunter, Sivo, & Cornell, 2004–2005; Ndubisi, 2006) because it provides quantifiable variables for understanding predispositions to adoption. This section of the article discusses the development and use of some relatively new theories to predict individual adoption of technology—the TAM and its successor, the UTAUT. This article addresses the two theories together because of their close theoretical ties.

The Theoretical Bases of the TAM and UTAUT

The theory of reasoned behavior (and its predecessor, the theory of reasoned action) is a popular theory as a way to understand the relationship between intention as a mediator between action and attitudes (Ajzen, 1996). This theory postulates that an individual's behavior is a result of their attitudes about the expectation of a behavior and social norms about a particular behavior (Ajzen & Fishbein, 1980). Attitudes are constructed based on an individual's perceptions (this article discusses perceived ease of use and perceived usefulness as the foundation of computer attitudes below) about an innovation (Agarwal & Prasad, 1998b).

The TAM—Key Concepts

F. Davis's research (1989) was some of the first research to study how an individual's perceptions of a technology innovation affect the eventual use of that technology. Influenced by both social cognitive theory and decision-making theories, Davis identified two perceived characteristics about an innovation that he believed to predict the usage outcomes. The first, perceived ease of use, is the "degree to which a person believes that using a particular system would be free of effort" (F. Davis, 1989, p. 320). Davis linked perceived ease of use to self-efficacy because he believed ease of use was a similar outcome judgment. The second characteristic, perceived usefulness, is defined as "the degree to which a person believes that using a particular system would enhance his or her job performance" (F. Davis, 1989, p. 320). Perceived usefulness has been found to be a consistent influence of future individual use of a technology (Adams, Nelson, & Todd, 1992; Agarwal & Prasad, 1998a; Lippert & Forman, 2005).

F. Davis's (1989) work was important because it began the conversation about the importance of individual perceptions of a technology. A study done on mandatory information technology implementation by Massey, Montoya-Weiss, and Brown (2001) suggests that different groups within a population may also differ in their beliefs about perceived ease of use and perceived usefulness. Perceived usefulness may also be linked to how innovative a person may be—individual characteristics may influence how salient a particular technology is to a particular individual in their context (Venkatraman, 1991).

TAM Criticisms and Critiques

Does perceived ease of use equal self-efficacy? First, the idea that perceived ease of use can be directly mapped on to the concept of self-efficacy is flawed. In the original definition, perceived ease of use is a judgment about the qualities of a technology, but self-efficacy is a judgment about the abilities of an individual. This is not to say that there is not a link between ease of use and self-efficacy. Some suggest that perceived self-efficacy in a particular computer-based task may in turn influence the perceived ease of use (Agarwal, Sambamurthy, & Stair, 2000). In addition, although these two factors are important, strictly predicting user behavior based on ease of use and usefulness ignores many other factors, as illustrated by later models. Later research (Venkatesh, 2000) suggests that, indeed, self-efficacy is separate conceptually from perceived ease of use.

Individual differences absent in TAM. One of the most salient criticisms of the TAM is the lack of acknowledgement of individual differences (Agarwal & Prasad,

1999). Beliefs and attitudes about technology are influenced by more than the perceived ease of use and perceived usefulness of the product. The original TAM does not take into account prior experience, age, gender, and many other characteristics that may influence attitudes about technology, which in turn influence intention to use an innovation.

The UTAUT—Key Concepts

In 2003, a study by Venkatesh and colleagues examined eight of the most common theoretical frameworks and models used to understand the individual adoption and use of technology. Social cognitive theory, the theory of reasoned action/behavior, and IDT were all included as previously used constructs. The study then empirically compared these individual theories through a within-subjects, longitudinal validation of the various models with subjects in four work-based environments. The eight models individually explained 17 to 53% of the variance in use of various information technologies (Venkatesh et al., 2003).

The more salient characteristics of the eight models were brought together to form a unified model for understanding technology acceptance. The UTAUT includes four key determinants of use and four moderators of individual use behaviors. In Table 3, the original author's representation of the model demonstrates the highly complex nature of this proposed model.

Because of the model's intricacy, a full discussion of all the influences in this model is beyond the scope of this article. However, a summary of the key proposed determinants and modifiers and their theoretical bases are provided.

Ultimately, the study on the development of the UTAUT suggested that performance expectancy, effort expectancy, and social influence for predicting behavioral intention in turn predicted usage behaviors. Gender, age, experience, and the perception of voluntariness of change were all moderating factors for intention (Venkatesh, 2000).

UTAUT & TAM: Concerns, Critiques, and Future Research

This section of the article briefly reviews some of the more salient critiques and criticisms of the TAM and UTAUT as well as some directions for future research using the model.

UTAUT: An untested model? The UTAUT is still a relatively new model. Whereas the TAM has enjoyed a (relatively) long history in the research literature, the UTAUT, first published in 2003, has had limited use in the research literature since its publication. Further validation and replication of the UTAUT model is essential.

Attitude and self-efficacy. The original model for the UTAUT included measures for self-efficacy and attitude toward computers. However, the analysis suggested that computer anxiety, computer self-efficacy, and attitudes were completely captured by the different expectancy processes measured (primarily effort expectancy but also process expectancy). An examination of the items used in estimating the UTAUT indicates that the UTAUT is measuring not an overall computer self-efficacy but a specific self-efficacy toward a particular technology (Venkatesh et al., 2003). There are the beginnings of a research base about the differences between general and specific computer self-efficacy (Agarwal et al., 2000), which may change the

TABLE 3
Description of key determinants and moderators in the United Theory of Acceptance and Use of Technology model

		Description
Key determinant	Performance expectancy	The degree to which an individual believes that a technology will assist them in performing job duties, this is influenced by previous constructs of perceived ease of use (F. Davis, 1989)
	Effort expectancy	The degree to which an individual perceives a particular technology to be easy to use (adapted from F. Davis, 1989)
	Social influence	The degree to which an individual feels social pressure to use a particular information technology, based on the construct of subjective norm from the theory of reasoned action (Ajzen & Fishbein, 1980)
	Facilitating conditions	The degree to which an individual believes that his or her organization is supporting the change
Moderator	Description	
	Gender	Male, female
	Age	Continuous
	Experience	Ordinal—low, medium, high
	Voluntariness of use	A categorical variable (high, low)

influence of computer self-efficacy, particularly outside of formal organizational settings.

Are TAM and/or UTAUT appropriate for educational settings? It has been suggested in a study by Wolski and Jackson (1999) that the TAM model does not catch the intricacies and relevant influences specific to the educational institution. Although an educational environment shares some characteristics with a business environment, the influences of technology change on relationships with students and teacher identity are not captured in the TAM (Wolski & Jackson, 1999). However, the UTAUT does suggest gender and age interactions with social pressure; women and those with less computer experience were found to have higher effort expectancies. With education being a female-dominated profession (particularly in the K-12 arena), further research should investigate the influence of social factors in this area.

Does use equal acceptance? Implications for informal learning. Whereas the UTAUT seems valuable for formal organizations implementing a broad-reaching information technology, it is still unclear if it will be applicable to more informal types of learning. The key determinants identified by the UTAUT may shift in

importance depending on environment. Although the UTAUT is one of the few models to try to incorporate the concept of willingness or volunteerism for the use of a new technology, it only accounts for it on a categorical binary variable (high/low). By studying technology use behaviors and intentions in a mandated environment, the model is not truly measuring technology acceptance because the individuals ultimately do not have a choice as to whether to accept a technology. Future research may show different levels of voluntary behavior influence the acceptance and use of technology.

Summary and Implications

The TAM and its successor, the UTAUT, are two models used frequently to specifically study technology adoption in formal organizations. Although these two models capture much valuable information about intentions and use, the UTAUT is still new and relatively untested. Furthermore, additional research is needed to understand how the UTAUT may be applied in organizations outside of corporate institutions, such as educational institutions and informal learning situations.

Discussion

Technology Adoption Is a Complex, Inherently Social, Developmental Process

Looking across adoption and diffusion theories, there is an abundance of different factors that influence whether an individual will choose to adopt a technology. These factors constantly interact to inhibit and/or promote change (Adler & Clark, 1991). Understanding or controlling any one factor will not guarantee success; even if an innovation is the most useful, contextual factors can lead to nonadoption (Rogers, 1995). Personal factors, characteristics of the innovation, and influences of the individual's context will all shape the ultimate decision and persistence with a technology. With the exception of perhaps the innovator himself or herself, technology adoption is innately social, influenced by peers, change agents, organizational pressure, and societal norms (Rogers, 1995). The process of technology adoption can be altered through these social interactions (Hord et al., 1987). Lastly, the adoption and diffusion process can be viewed as having the broad characteristics of a developmental theory—change is relatively slow and relatively orderly. Most adoption theories discuss technology adoption in terms of stages, and although most of the stages are not clear cut, they do suggest a progression of knowledge and understanding.

Individuals Construct Unique (but Malleable) Views of Technology That Influence Adoption

Individuals construct beliefs about technology based on a variety of personal factors including prior experience, beliefs about specific and general abilities (Agarwal et al., 2000), stable personality traits (Agarwal et al., 2000; Wood & Swait, 2002), and mandated versus voluntary use of technology (Jones & Clarke, 1995; Venkatesh et al., 2003). These beliefs are malleable. Structured educational experiences (Agarwal & Prasad, 1998a), personal experimentation, and social pressures and/or change agents (Hord et al., 1987) are suggested as possible moderators for attitudes toward innovation.

Successfully Facilitating a Technology Adoption Needs to Address Cognitive, Affective, and Contextual Concerns

Because of the complexity of factors that mediate and moderate technology use, any organization or population considering the implementation of a technology innovation must be able to develop a process to handle multiple personal aspects—cognitive, affective, and contextual. Cognitive concerns include how compatible an innovation is with existing understandings of similar innovations and tasks as well as how the innovation will benefit the users' current task understanding. Currently, no one model can account for all these concerns. For example, although a teacher can express cognitive understanding that a piece of technology is important to his or her job (as accounted for by the TAM), if the teacher views the personal cost as too high (CBAM) a successful adoption is less likely to occur.

Implications for Future Research

Lastly, this article addresses some of the gaps in the current literature and directions for future research. Can the models presented here help researchers understand the process of technology adoption outside the traditionally studied formal organization? What areas of future research are available in this field?

Addressing affect in technology adoption. Supporting adoption means recognizing that a technology change does have affective ramifications. Research in educational change has only begun to examine teachers' responses to change (Van Veen & Sleegers, 2006), and little research has focused specifically on the affective aspects of technology deployment. However, there is some anecdotal evidence suggesting that technology implementation taps emotional resources (Cramer, 2006). Although the CBAM addresses affect in terms of cognitive and contextual concerns, it still does not account for affective responses to that change. The research currently cannot provide a roadmap for anticipating affective responses to technology, nor is there an empirical basis for understanding the influence of emotions on the adoption process. However, the implications of social cognitive and adoption theories suggest that just as the context can influence the beliefs and emotional response, emotions may influence beliefs, context, and culture (Bandura, 1986).

Consider the informal within the organization. Most of the research specifically on technology adoption has centered on adoption in a work environment, with the innovation being a mandated change for employees. Although work-centered use of information technology is critical, technology has infiltrated far deeper into everyday life than just formal professions. Home computers, cell phones, and other technologies that were once regulated to the elite or to the office are now staples in the personal and work lives of many. In 1985, approximately 200,000 people subscribed to cellular phone service in the United States. In 1995, that number was 28 million. By 2005, 190 million individuals in the United States subscribed to a cellular phone service (Cellular Telecommunications & Internet Association, 2005). This use of technology is much more voluntary (perhaps outside of social pressures). Voluntary adoption has been suggested to play a mediating role in attitudes toward technology (Garland & Noyes, 2003). Because most of the adoption models developed deal with top-down mandated adoption (even with the UTAUT, although voluntariness was a factor measured, it was still within the scope of a

work-based environment, so presumably the acceptance could never be completely voluntary), investigation is needed into the various processes that influence and regulate informal adoption of technology.

Ultimately, even informal learning and adoption affect the organization in some way. Although the advent of the cell phone was probably not anticipated to influence the school organization, technology can facilitate bleed-over, merging personal and work lives (Chelsey, 2005). Schools now have to deal with students using cell phones in the classroom, bringing to the forefront more personal technologies that in turn influence classroom environment. Future research should point to how informal technologies influence the use and implementation of technologies in formal settings.

Technology adoption: A constant uphill battle? Technology adoption has become a Sisyphusian task. As Sisyphus was condemned to eternity of pushing a boulder up a mountain, only to have to roll it back down again, the average individual is doomed to a cycle of continual technology implementation. About the time an individual adopts a technology, a new one is developed and marketed, requiring a new adoption cycle. What the research on adoption and diffusion currently lacks is an understanding of how this constant adoption and readoption will affect and influence future adoptions. There is a presumption that the younger generations who grow up with computers will be more accustomed to them and adjust more easily to new systems. However, at this time, there is no empirical or longitudinal data to support this idea. Venkatesh et al.'s (2003) work on the UTAUT suggest the opposite—one inference from these data is that there might be a critical period when technology adoption ceases to become quite so easy, when cognitive flexibility toward computer systems diminishes. Additionally, Rogers (1995) and some versions of the TAM suggested that experimentation and experience with a similar technology will facilitate the adoption process. Instead, however, Lippert and Forman (2005) found that prior similar experience was actually negatively correlated with technology use. This suggests that there is an interference effect of the prior technology learning—that knowing more technology is actually a detriment to learning new technology. Clearly, the discrepancies in the research suggest that additional research on the effects of continual cycles of adoption are important for the future.

How does one understand useful*?* Perceived usefulness is one of the most prevalent concepts in much of the adoption literature (Agarwal & Prasad, 1999; F. Davis, 1989; Rogers, 1995) and has even been suggested to be more important than perceived ease of use (Lippert & Forman, 2005). What is lacking in current literature is an understanding of how an individual judges what is useful in an information technology system. Developers and designers create functions and features that they propose to be useful, only to have them discarded as not useful by the users. Usability research studies ease of use, but how the decision-making processes individuals go through both to perceive an innovation as compatible and how that perception of compatibility can be changed still need to be researched. Adoption does not equal acceptance (Jaffee, 1998), and understanding and facilitating the process of acceptance may be more important than adoption itself.

A negative cycle of adoption? A second gap in this literature is the lack of understanding about the possibility of a negative cycle of technology adoption. The

CBAM addresses concerns (particularly affective concerns) but does not explain the individual choice and adaptation to technology adoption. The UTAUT focuses on behavior but suggests that attitudes toward computers, self-efficacy, and computer anxiety concerns can be explained purely by effort expectancy, which seems contradictory to the value social cognitive theory puts on these constructs (Bandura, 1986; Venkatesh et al., 2003). Research on goal orientation suggests that for some, failing at one's goal results in negative emotions and, potentially, future goal-setting behavior (Cron, Slocum, VandeWalle, & Fu, 2005). An individual's failure to successfully learn a technology may induce a negative cycle of nonadoption. This negative cycle may affect self-confidence and trust in computer systems (de Vries, Midden, & Bouwhuis, 2003) and, ultimately, may have implications on self-efficacy when using technology as well. Whether the absence of influence of self-efficacy and attitudes toward computer use is because of a mandated situation or a limitation of the measures used in the UTAUT has yet to be seen. Further investigation of the findings and validation of these models is warranted.

Implications for Educators and Administrators

Whether to implement a technology may not be a feasible choice for many school administrators. Little empirical research has been done examining the decision-making processes districts go through in deciding on a particular technology beyond case studies (Elias, Cafolla, & Schoon, 2000; Josephs, 2001). External forces such as state standards, cost, available funds, security, and technical support may limit not only the overall decision to deploy an innovation but also which specific technology will be adopted. Whereas the teachers' personal views on factors like ease of use for a particular technology may be considered, it is generally not the defining factor when making major technology decisions.

For administrators preparing for an implementation of technology, adoption theory may seem too complicated to apply one theory that will account for all aspects of a change. Most current models of adoption are focused on one particular aspect of the process. This article suggests that a broader view of adoption is necessary for understanding adoption of technology. Cognitive approaches must be understood in context; beliefs are influenced by environment and emotions, and emotions influence the environment. Successful facilitation of adoption is most likely to occur at the intersection of the cognitive, affective, and contextual factors. In terms of implementation, both theories provide an aspect of this process. The TAM and UTAUT may provide a partial prescriptive framework for the adoption process by suggesting administrators look at issues such as the following: Is this a mandated adoption? Will teachers feel that the technology is important and useful to their daily teaching? In turn, the CBAM can assist administrators during the implementation of the technology by providing a framework for moving individuals along the various levels of teacher development.

Preparing for a technology deployment means looking beyond the cognitive selling points of a technology. Current practices in deploying information technology frequently focus on the cognitive aspects by emphasizing how a new technology is a better choice than previous technologies or how it will make a teacher's job easier. This strategy is logical and easy to implement; however, this approach is not enough. Evangelizing the benefits of a technology is only useful if the benefits are embraced by the environment. It is not only teachers' cognitive beliefs

about perceived value but also the school and district's support that emerge as an important characteristic of adopting and maintaining innovation in schools (Barnes, 2005; Owston, 2007). Teachers need to believe not only that the innovation is important and useful but that the school district is flexible with the support of that change.

Recent application of the UTAUT to a study of deployment of laptops for business faculty suggests that an individual's voluntariness, as opposed to mandated use, is one of the more salient predictors of adoption (J. E. Anderson, Schwager, & Kerns, 2007). This suggests that when decisions about technology are made at the district level, this perceived lack of control is an important factor that must be considered. Although it is difficult if not impossible to make technology adoption a free choice in a formal environment, building in flexibility for teachers to have the perception of a choice may improve adoption facilitation.

Finally, administrators need to keep in mind that technology adoption implications extend past direct pedagogical integration. Changes in peripheral systems like student information systems, payroll systems, and even changes in the phone system may have an unanticipated effect on teachers' environments and, therefore, attitudes toward technology. Even changes in informal technology can affect the dynamics of the school. Informal technologies like cell phones blur the lines between social, work, and home lives. These informal technologies may in turn result in a more formal use, such as mandating cell phones as a means for an emergency contact. As technologies become more pervasive, so do the pressures to acquire the skills to successfully use or leverage them. Administrators may need to recognize that just as the lines between informal and formal technologies are blurred, so too are the lines that delineate pedagogical and nonpedagogical technologies.

Conclusion

Supported by this examinations of Rogers's innovation adoption and diffusion theories, the CBAM, the TAM and the UTAUT, some general conclusions can be drawn about how adoption diffusion theories would specifically influence the introduction of a new technology. First, technology adoption is a complex, inherently social, developmental process. Secondly, individuals construct unique (but malleable) perceptions of technology that influence the adoption process. Lastly, successfully facilitating a technology adoption needs to address cognitive, emotional, and contextual concerns.

Future research on adoption may examine the consequences of technology to create a holistic understanding of how technology change influences the organization and the individual. Whereas technology adoption may be viewed in terms of ramp-up time, or how much time is lost in the learning of technology, researchers should also be looking at how technology changes alter individuals' views of technology. For example, how does a negative experience with technology influence a teacher's use of technology? If a teacher becomes frustrated or angry at the technology, does this change the way they interact with technology or choose to implement it in the future? How do a teacher's interactions with technology influence his or her students' future perspectives on technology? So much of the current research focuses on technology adoption as a find-and-replace strategy, but what may be perceived as a slight change may have deeper repercussions for the future.

This article suggests that the future of adoption research should focus not just on adoption and implementation of information technology in the formal organization but how individuals understand, adopt, and learn technology outside of the formal organization. Adoption models generally focus on the specific characteristics of the context, the individual, and the innovation to predict future use. Whereas much research has been done in the past 50 years about the processes individuals go through to adopt and adapt to an innovation, the constant bombardment of new information technologies makes understanding the hows and whys of user technology adoption a particularly pressing issue now and in the future.

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