JRTE | Vol. 43, No. 4, pp. 343–367 | ©2011 ISTE | iste.org

Understanding the Influence of Perceived Usability and Technology Self-Efficacy on Teachers' Technology Acceptance

Heather Holden
Roy Rada
University of Maryland Baltimore County

Abstract

The Technology Acceptance Model (TAM) represents how users come to accept and use a given technology and can be applied to teachers' use of educational technologies. Here the model is extended to incorporate teachers' perceived usability and self-efficacy measures toward the technologies they are currently using. The authors administered a survey to K–12 teachers in two rural school districts in Virginia, and 99 teachers responded. We then analyzed the responses with both reliability statistics and general linear modeling techniques. The results indicated that the incorporation of perceived usability into the TAM explained more variance and was more influential to TAM elements than its absence, thereby supporting the importance, positive influence, and necessity of evaluating usability when investigating educational technology acceptance and usage behavior. Furthermore, the study found teachers' technology self-efficacy (TSE) was more beneficial to the TAM than their computer self-efficacy (CSE); however, this impact might vary for the evaluations of different populations and technologies. (Keywords: Education technology, Technology Acceptance Model, K–12 teaching, IT diffusion and adoption, perceived usability, self-efficacy)

User acceptance, satisfaction, and perceived usability of innovative technologies are crucial to the diffusion of those technologies. Human–computer interaction research seeks to understand and utilize the determinants of user technology acceptance to influence the technology design and implementation processes and minimize user resistance. The emphasis is placed on understanding users' usage behaviors toward the technology through usability testing and evaluation methods, which are targeted to ensure that users can operate a technology efficiently, effectively, and satisfactorily. However, researchers place less emphasis on the evaluation of the users' characteristics (or vital psychological elements) that considerably contribute to users' perceptions toward the technologies. Essentially, there is a reasonable assumption that usability is a prerequisite of acceptance; thus, if a technology is considered highly usable and useful, it will most likely

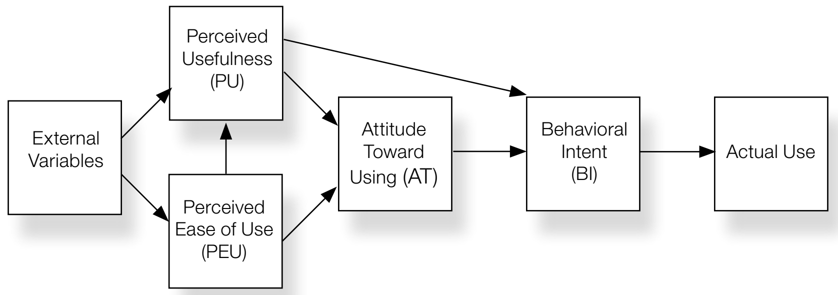

Figure 1. Original Technology Acceptance Model (TAM) (Davis, 1989, cited in Szajna, 1996, p. 86).

be highly accepted by its targeted users. This is often not the case, as many technologies have been perceived as highly usable and useful but were never accepted by the targeted users (Dillon, 2001). Such technologies were developed without an adequate understanding of the targeted user population.

Research has shown that users' psychological variables (cognitive style, personality, self-efficacy, demographics, user-situational variables, etc.) can have different levels of influence on user technology acceptance (Alavi & Joachimsthaler, 1992). However, few human–computer interaction researchers have attempted to combine both core technological (those pertaining to system usability) and psychological (those pertaining to the users' characteristics) variables into a unified theory for design and implementation purposes (Dillon, 2001). The closest and most researched theoretical model to represent attributes from both variable categories is the Technology Acceptance Model (TAM). The TAM is a theoretical model that predicts how a user comes to accept and use a given information technology. It specifies casual relationships among external variables, belief and attitudinal constructs, and actual usage behavior (Hubona & Kennick, 1996). The model suggests that when users are presented with a particular information technology, a number of factors, notably perceived usefulness and perceived ease of use, influence their decision of how and when they will use the technology. The original TAM models users' cognitive, affective, and behavioral responses toward the particular technology in question. The perceived usefulness and perceived ease of use elements represent users' cognitive responses to using the technology. These cognitive responses then influence the users' affective response (attitude) toward using the technology. The users' affective response ultimately drives their behavioral response (i.e., their behavioral intention to use) toward technology (Burton-Jones & Hubona, 2005). Figure 1 presents the primary elements of the original TAM, which include perceived usefulness (PU), perceived ease of use (PEU), attitudes toward using (AT), and behavioral intention to use (BI). Collectively these elements predict the users' actual system usage (i.e., usage behavior).

The TAM can be used to evaluate (a) new technologies, by measuring the behavioral intention to use (BI); and/or (b) currently used technologies, by measuring usage behavior (UB—e.g., actual use).

Many researchers in various disciplines have developed a multitude of revisions and extensions to the TAM (Burton-Jones & Hubona, 2005; Davis, 1993). Nevertheless, a critical limitation of the TAM is its lack of emphasis on the system characteristics, which may influence user acceptance, as in usability evaluations. TAM studies have shown that this model can explain approximately 50% of the variance in technology acceptance levels (Venkatesh & Davis, 2000). Could it be that some of the unexplained variance is clarified by users' perceived usability of the technology?

The importance of usability and its evaluations are relatively new concepts (i.e., within the past 2–3 decades). The original TAM was created prior to the increase in demand for technology usability assessments and, therefore, does not include essential measures relating to users' perceived usability of the technology. In this study, four usability metrics are added to the perceived ease of use element of the TAM to assess whether perceived usability helps explain more variance in users' technology acceptance levels. This study evaluates teachers' technology acceptance of the technologies they are currently using; thus, the behavioral intention to use is eliminated and the focus is on usage behavior. Ideally, incorporation of the TAM, or even some of its elements, into usability testing initiatives might help capture the full spectrum of understanding users' technology acceptances and predict their technology usage behaviors.

Another concern this paper addresses is the relationship between self-efficacy and user technology acceptance. Self-efficacy is one's belief in his or her ability to execute a particular task. Venkatesh and Davis (1996) found that computer self-efficacy (CSE) acts as a determinant of perceived ease of use (PEU) both before and after hands-on use with a system (V. Venkatesh & Davis, 1996). Other researchers have also found an influence of CSE on the TAM (Chen, Huang, & Shih, 2002; Downey, 2006; Strong, DiShaw, & Brady, 2006). Researchers have also evaluated the influence of users' self-efficacy toward the type or subject of the targeted system, such as Internet and e-learning self-efficacy, on the TAM. However, TAM research has not yet evaluated the users' self-efficacy toward the particular technology in question (i.e., TSE) and the relevance it may have on their acceptance. This study assesses the influential differences of both CSE and TSE and finds TSE to be more influential than CSE to the TAM outcome. This study evaluates only the four elements of Figure 1 directly affected by the concerns investigated: external variables (EV), perceived ease of use (PEU), perceived usefulness (PU), and attitudes toward using (AT).

Literature Review

Usability and Technology Acceptance

Shackel (1991) described usability as a system's capability to be used by humans effectively and easily. His idea of an acceptable system is one that satisfies its users' requirements for utility, usability, and cost. Usability may be seen as a combination of the following goals: effectiveness, efficiency, safety, utility, learnability, and memorability (Preece, 1994; Preece & Rodgers, 2002). In the original Technology Acceptance Model (TAM), perceived ease of use represents the degree to which a technology will be free from effort, thus measuring the degree of users' perceived understanding, mental effort, ease of use, and flexibility of a given technology (Davis, 1989). Venkatesh (2000) provided the most noted TAM extension in relation to usability as he attempted to identify the key determinants of the perceived ease of use element of the TAM. Venkatesh theorized the existence of anchor and adjustment factors, which affect perceived ease of use. He suggested that before users have experience with the system, they are expected to anchor (i.e., CSE, perceptions of external control, computer anxiety, computer playfulness) their system-specific perceived ease of use of the new system to their general beliefs regarding computers and computer use. Additionally, as the users' experience with the system increases, they are expected to adjust (i.e., perceived enjoyment and objective usability) their system-specific perceived ease of use to reflect their system interactions.

Venkatesh (2000) evaluated his anchors and adjustments on the perceived ease of use with three populations: 70 employees from a retail electronic store on a new help-desk system, 160 employees of a real estate agency on a new property management system, and 52 employees on a new payroll application. He found that these variables can explain up to 60% of the variance in a technology's perceived ease of use, twice the amount currently understood. He also found perceived ease of use to be the primary driver in technology acceptance, adoption, and usage behavior. Thus, according to his research, individual's general beliefs toward computers are significantly strong determinants of system-specific perceived ease of use, even after system experience. Unfortunately, he evaluated only objective usability (i.e., the ratio of time spent by the subject to the time spent by the expert on the same set of tasks), which did not account for the users' subjective usability perceptions.

Usability is especially important for the educational domain. The failures of an educational system may stem from the lack of pedagogical support within the systems (Maurer, 1997; Turoff, 1995; Wade & Lyng, 2000). However, many software development companies do not have instructional design processes and evaluation procedures for teachers and/or students prior to distribution (Higgins, Boone, & Williams, 2000; Mills, 2001; Sugar, 2001; Williams, Boone, & Kingsley, 2004). Teachers wonder whether the design of educational software meets the instructional requirements for flexibility and attention to individual needs (Hinostroza & Mellar, 1993; Shiratuddin & Landoni, 2002). Nonetheless, literature on the usability of educational software remains scarce (Williams et al., 2004).

Self-Efficacy and Technology Acceptance

As previously mentioned, self-efficacy is one's belief in his or her ability to execute a particular task or behavior (Bandura, 1986). More specifically, CSE measures one's confidence in mastering a new technology (Compeau & Higgings, 1995). If a person has a high CSE, then he/she believes he/she will be successful in using the technology, and if a person demonstrates low CSE, then the person may believe he/she will have difficulty using the technology purposefully on his/her own (Lai, 2008). Venkatesh and Davis (1996) found that CSE acts as a determinant of perceived ease of use both before and after hands-on use with a system (Venkatesh & Davis, 1996). Other TAM researchers have found an influence of CSE on the TAM (Chen et al., 2002; Downey, 2006; Strong et al., 2006).

TAM researchers have also evaluated the influence of users' e-learning self-efficacy (Grandon, Alshare, & Kwan, 2005; Park, 2009) and internet self-efficacy (Lai, 2008; Ma & Liu, 2007) on their technology acceptance. E-learning self-efficacy refers to the personal confidence in finding information and communicating with an instructor within the e-learning system and the necessary skills for using the system. E-learning self-efficacy has been found to have an indirect effect on students' intentions through perceived ease of use (Grandon, et al., 2005). However, Park (2009) found that e-learning self-efficacy was the most important construct, followed by subjective norm, in influencing the behavioral intention to use e-learning.

Internet self-efficacy focuses on how one believes he/she can accomplish (i.e., establish, maintain, and utilize) the Internet now or in the future (Lai, 2008). Ma and Liu (2007) argued that Internet self-efficacy is more than a judgment of one's capability of applying internet skills; it is a measure of individual specific skills in using an Internet browser. They found internet self-efficacy explained 48% of the variation in perceived ease of use and the full model explained 80% of the variance in of healthcare professionals' behavioral intentions to use web-based medical record applications (Ma & Liu, 2007).

Self-efficacy can also influence teachers' perceptions of interactive classroom technologies. Albion (2001) found the most significant predictor of self-efficacy for technology use is the frequency of teachers' technology usage. Attitude and self-efficacy significantly influence computer use in the classroom (Herman, 2002). Improvement in self-efficacy and development of positive attitudes can increase classroom technology usage (Delcourt & Kinzie, 1993). Clark (2000) investigated 28 urban middle school teachers' perspectives of their technology usage. Results indicated teachers believe technology is an essential component of their classrooms and more technology is needed. They reported opposing attitudes in relation to the need for more technology training, and most teachers felt confident in their ability to use technology.

Fordham and Vannatta (2005) assessed 177 teachers' characteristics to identify the specific indicators that predict classroom technology usage. They concluded that time commitment to teaching, openness to change, and sufficient training are the best predictors of usage. Additionally, teachers with high self-efficacy and openness to change were more likely to use technology in instruction. Schechter (2000) discovered a significant relationship between teachers' comfort and proficiency with using technology and the degree to which they integrate it in their classrooms. An evaluation of teachers' self-efficacy toward technology usage must also be considered when assessing their attitudes toward technology usage.

Teachers' Attitudes and Technology Acceptance

Teachers who demonstrate positive attitudes and perceptions as well as high self-confidence toward technology usage may be more likely to utilize technology for instruction. Additionally, high technology acceptance may alleviate second-order barriers (i.e., increasing teachers' beliefs toward educational technology and their willingness to change teaching practices to utilize technology). Personal factors, including subject matter, gender, and teaching experience, are strongly associated with teachers' attitudes and perceptions toward classroom technology usage (Jimoyiannis & Komis, 2007). Furthermore, teachers' attitudes on the usefulness of such technologies are significant in determining their intentions to use them (Hu, Clark, & Ma, 2003; Ma, Andersson, & Streith, 2005).

Teachers' attitudes toward technology usage are an essential factor in assisting successful classroom technology integration (Bitner & Bitner, 2002). Sheingold and Hadley (1990) studied teachers' integration of computer software into their classrooms. Technologies evaluated were word processing tools, instructional software, analytic and information tools, programming and operating systems, games and simulations, and graphics and operating tools. It was discovered that teachers' attitudes toward computers and educational software can significantly influence their students' attitudes toward the technology if adequate support and time for teachers to learn the technology is provided. Years later, teachers' attitudes are still an important part of technology infusion into the classroom environment (Demetriadis, Barbas et al., 2003).

Teachers' educational beliefs are strong indicators of their planning, instructional decisions, and classroom practices (Czerniak, Lumpe, Haney, & Beck, 1999; Pajares, 1992). Crawley and Koballa (1992) found that attitude is the greatest predictor of science teachers' intention to use inquiry-based teaching methods critical to reform efforts in Texas. ChanLin (2005) surveyed 363 teachers to assess their perceptions about approaching technology. The study inquired about environmental, personal, social, and curriculum issues relating to technology integration. Results indicated that teachers who embrace creative teaching methods tend to have higher positive attitudes toward technology use in the classroom. Norton and McRobbie (2000) investigated the relationships between teachers' beliefs about teaching mathematics, their practices, and their attitudes toward using computers in their teaching. It was discovered that these contextual factors significantly contributed to their resistance to technology integration. Thus, a relationship exists between attitudes toward and usage of instructional technology.

Brownell, Haney, and Sternberg (1997) questioned teachers and administrators about their perceived needs for technology as part of professional development experiences for teachers. Whereas Seventy-seven percent of the respondents stated their district's teachers have positive attitudes toward technology in the classroom, 90% reported the same for their administrators; however, only 17% perceived that teachers in their district were skilled enough to integrate technology into their teaching. These past studies stress the importance of teachers' attitudes toward technology use in the classroom.

TAM Evaluations of External Variables and Attitude toward Using

External variables are essentially a variety of variables that are expected to influence users' technology acceptance behavior. These "individual difference factors" consist of, but are not limited to, user characteristics (i.e., age, self-efficacy, anxiety, playfulness, prior experience, level of education, etc.), political influences, and organizational factors that are typically pre-existing before the study takes place (Szajna, 1996). Although some previous TAM studies acknowledged that the existence of external variables has an impact on perceived usefulness and perceived ease of use, most of the TAM studies ignored the evaluation of such variables. Consequently, most TAM studies and extensions do not adequately account for users' external difficulties and psychological interactions with given technologies. The role of external variables affecting usage behavior within the TAM has not been well investigated (Hubona & Geitz, 1997), even though Venkatesh (2000) suggested that the initial drivers of perceived ease of use are largely dependent on individual difference variables and situational characteristics.

TAM research conducted by Hubona and associates presents perhaps the most extensive evaluations of the impact of external variables on actual system usage (i.e., usage behavior) (Burton-Jones & Hubona, 2005; Hubona & Burton-Jones, 2002; Hubona & Geitz, 1997; Hubona & Kennick, 1996). Hubona's research is centralized around understanding usage behavior (UB) with the elimination of the behavior intention to use (BI) element. Hubona's research found various direct connections of external variables to perceived usefulness, perceived ease of use, attitudes toward using, and usage behavior; thereby, discovering that belief constructs are not the sole influence on usage behavior. His research also re-validated the 'attitudes toward using' construct, which is also typically eliminated from TAM studies. A common theme in this particular body of research is the necessity of further investigation of the direct and indirect effects of external variables to better understand the generalities of their influences (Burton-Jones & Hubona, 2005; Hubona & Burton-Jones, 2002; Hubona & Geitz, 1997).

Theoretical Framework

Essentially, TAM researchers neglect to evaluate the users' perceived usability of system characteristics, and researchers neglect to evaluate users' psychological characteristics when assessing users' technology acceptance. Researchers want to understand the connection between the user and the technology and use this connection to predict users' technology acceptance. Understanding the full user-system spectrum can help identify problematic characteristics that can be resolved in future technology design and implementation procedures. Furthermore, previous studies that evaluated the influence of self-efficacy on users' technology acceptance did not assess whether users' self-efficacy of a particular technology may play a part in users' acceptance of that technology. The purpose of this study is to evaluate the main effects of users' perceived usability and technology self-efficacy on their technology acceptance. This study will address the following two research questions:

- Can the variation in the TAM be better explained by adding usability metrics into the perceived ease of use element?
- Which is more influential to the TAM outcome, users' technology self-efficacy or computer self-efficacy?

Methodology

Hypotheses and Research Models

To address the research questions, this study presents a research model for each of the following two hypotheses:

- **H1:** Redefining the perceived ease of use element to include users' perceived usability will explain more variance and be more influential to the TAM elements of perceived usefulness and attitudes toward using.
- **H2:** Users' technology self-efficacy will be more influential to explaining their technology acceptance than their computer self-efficacy.

Hypothesis 1. As previously mentioned, perceived ease of use represents the degree to which a technology will be free from effort, thus measuring the degree of users' perceived understanding, mental effort, ease of use, and flexibility of a given technology (Davis, 1989). Venkatesh (2000) found PEU to be the primary driver in technology acceptance, adoption, and usage behavior. In his study, he evaluated the impact of objective usability on perceived ease of use. Unfortunately, objective usability does not account for the users' subjectively perceived usability. However, identifying users' subjective perceptions of a technology's usability may provide more insight into understanding their technology acceptance.

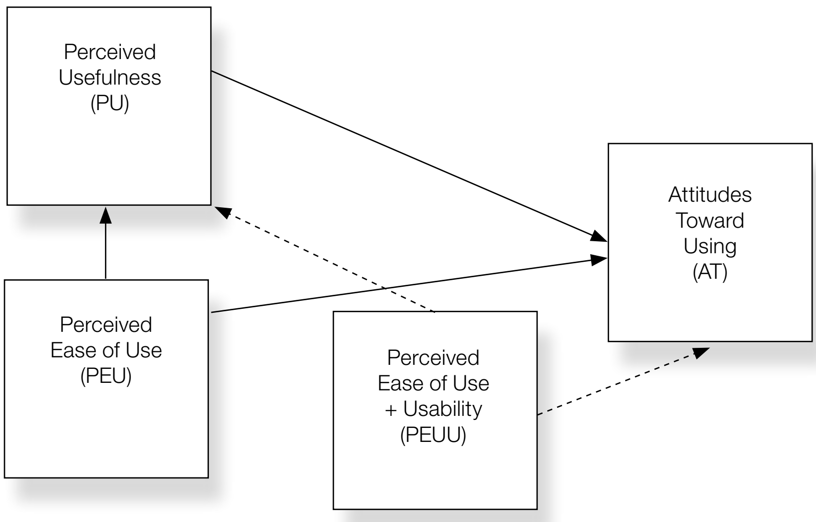

Figure 2. Research model for Hypothesis 1.

To assess hypothesis 1, this study incorporates additional usability measures into the proposed model to assess the influence of usability on usage behavior. Accordingly, four usability measures (learnability, functionality, navigation, and memorability) are added to the perceived ease of use element, thereby creating the construct perceived ease of use + usability (PEUU). Learnability is the ease of learning how to learn the system, functionality refers to the satisfaction of the system's incorporated features, navigation refers to the ease of operating the system intuitively, and memorability refers to the ease of remembering how to use the system. Figure 2 is the research model for Hypothesis 1, and the dashed arrows represent the relationships evaluated to address this hypothesis. This study evalutes both the original perceived ease of use and perceived ease of use + usability constructs to identify the benefit and possibility of subjective usability assessment in relation to technology acceptance. As research has proven and generalized that perceived ease of use directly influences perceived usefulness and attitudes toward using, this study does not present its connection to usage behavior.

Table 1 (p. 352) shows the individual questions for both the perceived ease of use and perceived ease of use + usability constructs. The constructs used a standard 7-point Likert scale (1 = strongly disagree, 2 = moderately disagree, 3 = somewhat disagree, 4 = neutral, 5 = somewhat agree, 6 = moderately agree, 7 = strongly agree), which are the same measures from Venkatesh (2000). The five measures for the PEU and PEUU constructs were adapted from existing TAM studies, such as Venkatesh (2000). However, the additional four PEUU measures represent usability measures adapted from Preece (1994).

Table 1. Perceived Ease of Use (PEU) and Perceived Ease of Use + Usability (PEUU) Measures

Statements	Measure	Element
My interaction with the technology is clear and understandable.	Understandable	PEU + PEUU
Interacting with the technology does not require a lot of my mental effort.	Mental Effort	PEU + PEUU
I find the technology to be easy to use.	Ease of Use	PEU + PEUU
I find it easy to get the technology to do what I want it to do.	Ease of Use	PEU + PEUU
I find the technology to be flexible to interact with.	Flexibility	PEU + PEUU
Learning how to perform tasks using the technology was easy.	Learnability	PEUU
The technology has good functionality (features).	Functionality	PEUU
I feel I have an intuitive sense on how to operate the technology.	Navigation	PEUU
I find it easy to remember how to perform tasks using the technology.	Memorability	PEUU

Table 2. Perceived Usefulness (PU) Measures

Statements	Measure	Origin
Using the technology improves my performance in my job.	Performance	Original PU (Davis, 1989)
Using the technology in my job increases my productivity.	Productivity	Original PU (Davis, 1989)
Using the technology enhances my effectiveness in my job.	Effectiveness	Original PU (Davis, 1989)
I find the technology to be useful in my job.	Usefulness	Original PU (Davis, 1989)
In my job, usage of this technology is relevant.	Relevance	(Viswanath Venkatesh & Davis, 2000)
I have no problem with the quality of the technology's output.	Output Quality	(Viswanath Venkatesh & Davis, 2000)

Table 3. Attitude toward Using (AT) Measures

Statement: All things considered, my using the technology is….		
Pairs		Origin
Bad	Good	Original AT (Davis, 1989)
Foolish	Wise	Original AT (Davis, 1989)
Unfavorable	Favorable	Original AT (Davis, 1989)
Harmful	Beneficial	Original AT (Davis, 1989)
Negative	Positive	Original AT (Davis, 1989)

Perceived usefulness and attitude toward using measures. Perceived usefulness is the degree to which the user believes using a specific technology will increase his or her job performance. Thus, the perceived usefulness construct, as presented in Table 2, measures the degree of perceived performance, productivity, effectiveness, and usefulness of a given technology (Davis, 1989). The construct used a standard 7-point Likert scale (1 = strongly disagree, 2 = moderately disagree, 3 = somewhat disagree, 4 = neutral, 5 = somewhat agree, 6 = moderately agree, 7 = strongly agree), which are the same measures from (Venkatesh, 2000).

The attitudes toward using element represents teachers' feelings toward the technologies they are using. Thus, the attitudes toward using construct, as presented in Table 3, consists of five pairs of feelings evaluating the degree to which the user feels the technology is good, wise, favorable, beneficial, and positive (Davis, 1989). For each pair, the instrument asked individuals

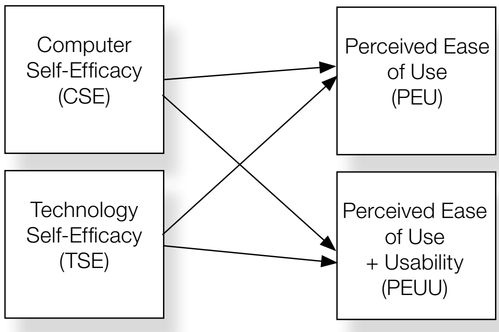

Figure 3. Research model for Hypothesis 2.

to rate the response items according to how they feel about using the technology on a 7-point semantic differential scale (i.e., good—extremely, quite, slightly, neutral, slightly, quite, extremely—bad).

As previously mentioned, actual system usage (i.e., usage behavior) and behavior intention to use are not presented in this paper because they are not directly affected by the evaluated independent variables. However, Holden (2009) found a direct connection of perceived ease of use + usability, perceived ease of use, perceived usefulness, and attitudes toward using to usage behavior. Additionally, perceived ease of use + usability was found to have a stronger connection and explain more of the variance in usage behavior than perceived ease of use alone. (Holden, 2009)

Hypothesis 2. Figure 3 is the research model for Hypothesis 2, and the dashed arrows represent the relationships evaluated to address this hypothesis. As research has proven and generalized that computer self-efficacy directly influences perceived ease of use, this study does not present self-efficacy's connection to perceived usefulness, attitudes toward using, or usage behavior. To further support Hypothesis 1, the influence of technology self-efficacy and computer self-efficacy on the perceived ease of use + usability is also investigated.

The computer self-efficacy construct for this study consists of 10 response items. The foundation for these response items, presented in Table 4 (p. 354), is directly related to the findings of Compeau and Higgings (1995) and Venkatesh (2000). As with most self-efficacy measurements, the construct used a 10-point Guttman scale (1 = not at all confident to 10 = totally confident) as described in Compeau and Higgins (1995). Venkatesh (2000) found direct influences of computer self-efficacy on perceived ease of use across three different populations. For this study, technology self-efficacy represents the user's personal confidence toward successfully and purposefully using the technology itself. The researchers evaluated general computer self-efficacy and technology-specific self-efficacy to identify the influential differences of both self-efficacies on the TAM outcome. The only change in the technology-specific self-efficacy construct is the statement "I could complete any desired task using the technology if…."

Table 4. Self-Efficacy Construct and Questions

Statement: In general, I could complete any desired task using any computer/Internet application if…
…there was no one around to tell me what to do as I go.
…I had never used a technology like it before.
…I had only the manuals for reference.
...I had seen someone else using it before trying it myself.
...I could call someone for help if I got stuck.
...someone else had helped me get started.
...I had a lot of time to complete the task for which the technology was provided.
...I had just the built-in help facility for assistance.
...someone showed me how to do it first.
...I had used similar technologies before this one to do the same task.

This hypothesis does not assume that self-efficacy is the only or best external variable to predict perceived usefulness or perceived ease of use, as other external variables might be equally important. Hypothesis 2 addresses a user's perceptions toward a particular technology relative to the user's general perceptions of a computer. Some studies, such as Venkatesh (2000), evaluated the influence of users' general computer perceptions on their technology usage but neglected to similarly evaluate these perceptions of a particular technology.

Subjects and Instrumentation

The target population for this study consisted of the teachers from two rural public school districts in Virginia, Accomack County and King William County. We selected these school districts as a matter of convenience and accessibility. Within these school districts, all students have access to numerous technologies and online programs to help them improve their academic achievement. All of the teachers have passed the state's technology proficiency requirements and have many technologies available to them. The school districts believe technology can offer a profound opportunity for their educational communities (including the administrations, teachers, staffs, and students). Incorporation of technologies into educational practices will create more engagement for students of the digital age and strengthen the teacher–student relationship, as teachers are typically not a product of the digital age. Furthermore, technology integration will allow school district administration and staff to operate more efficiently and effectively. Thus, analysis of technology acceptance for each population within the educational community can help assess the productivity of current technologies and predict the adoption of future technologies. The sample population (n = 378) for this study was K–12 teachers, one aspect of the educational community, from both school districts. These teachers had various levels of personal and classroom technology use, teaching practices, grade levels, and subjects taught. Participation in the study was voluntary and based on teachers' willingness to participate. Table 5 presents the frequency and percentage

Table 5. Teachers' Demographics

Measure	Items	Percent	N
Gender	Female	83.8	83
	Male	16.2	16
Age	23–30	19.2	19
	31–40	25.3	25
	41–50	27.3	27
	≥51	28.3	28
Teaching Experience	1–5 years	24.2	24
	6–10 years	24.2	24
	11–15 years	21.2	21
	≥16 years	27.3	27
Grade Level	Elementary school	28.3	28
	Middle school	11.1	11
	High school	16.2	16

Notes: Accomack County (N = 55), King William County (N = 44)

distributions of the respondents' demographics. Of the 378 surveys distributed to the teachers, 99 were returned, providing a response rate of 26.2%. The respondents consisted of 28 elementary, 11 middle, and 16 high school teachers. Of the 55 respondents, 83.8% of the respondents were females and 16.2% were males. The average age was 42 years old. The average years of teaching experience was 14.

This study implemented a survey to the targeted population in March 2008. The survey was divided into three sections, as presented in Table 6 (p. 356). The first section contains questions on the teachers' demographics (i.e., gender, age, teaching experience, and grade level taught) and computer self-efficacy. These second section contains questions to identify the technologies teachers are currently using. This section asked participants to write down one of the technologies they had identified and use it to complete the third section of the survey. The third section contained questions on the participants' perceived usefulness, perceived ease of use, attitudes toward using, and technology-specific general self-efficacy toward the identified technology.

Results and Discussion

The results are divided into two sections, the first of which provides the reliability analyses (i.e., Pearson's correlations and Cronbach's alpha) for each evaluated construct. The second section completes the hypotheses testing and validates the proposed research models using univariate and multivariate general linear modeling. Although previous studies have used structural equation modeling, it is not suitable when the underling variables are categorical and nonmetric (ordinal) data. As the data of this study is nonmetric and observes simultaneous impacts, generalized linear modeling was the best approach. Generalized linear modeling is a flexible statistical model that

Table 6. Survey Outline

Survey	Construct/Question
Section One	Demographics
	Computer self-efficacy
Section Two	Identification of current technologies used
	Selection of one technology
Section Three	Perceived usefulness
	Perceived ease of use (including perceived usability)
	Attitudes toward using
	Technology-specific self-efficacy

Table 7. Correlation Matrix and Cronbach's Alpha Results for Evaluated Constructs

Model Elements	Computer Self-Efficacy	Technology Self-Efficacy	Perceived Usefulness	Perceived Ease of Use	Perceived Ease of Use + Usability	Attitudes toward Using	Usage Behavior	Cronbach's Alpha
Computer Self-Efficacy	1							.916
Technology Self-Efficacy	.774**	1						.929
Perceived Usefulness	.236*	.508**	1					.874
Perceived Ease of Use	.238*	.488**	.624**	1				.899
Perceived Ease of Use + Usability	.247*	.518**	.611**	.974**	1			.929
Attitudes Toward	.243*	.524**	.650**	.652**	.677**	1		.940
Usage Behavior	.279**	.395**	.513**	.309**	.353**	.353**	1	.918

*Notes: Total sample (N = 99); bold numbers represent Pearson's correlations that are statistically significant (*p<.05, **p<.01)*

incorporates normally distributed dependent variables and categorical or continuous independent variables.

Reliability Analysis

Table 7 presents the Cronbach's alpha and Pearson's correlations results for the evaluated constructs. The Cronbach's alpha was statistically acceptable for all evaluated constructs, and the factor analysis showed all items within each evaluated construct belong to and measure the same concept. The correlation analysis reported constructs had positive, significant relationships (p<.05).

All of the constructs in this study are statistically reliable. We initially evaluated the constructs separately for both school districts to identify any differences among the school districts. After careful analysis, no major differences between the school districts in how their teachers accept and use job-related technologies were apparent.

Validity of Research Models

Hypothesis 1 results. Hypothesis 1 addressed whether perceived ease of use + usability will be more influential to the TAM than just perceived ease of use. Consequently, we evaluated the main effects of PEUU and PEU on perceived usefulness and attitudes toward using. According to the Pearson's correlations presented in Table 7, the relationship between PEUU and AT (r=.677, p<.000) was significantly stronger than the relationship between PEU and AT (r=.652, p<.000). Furthermore, the PEUU scale (α=.929) was also slightly more reliable than the PEU scale (α=.899). Table 8 (p. 358) presents the results of the GLM analysis for testing Hypothesis 1.

Analysis revealed large main effects of perceived ease of use on attitudes toward using (F [24, 74] = 5.459, p<.001, partial η2 = .639) and perceived usefulness (F [24, 74] = 2.987, p<.001, partial η2 = .492), which were both significant per Wilks' Lamba =.265, F (24, 74) = 2.872, p<.001, partial η2 = .486). According to the adjusted R-squared, PEU explained 52% of the variance in teachers' attitudes toward using and 33% of their perceived usefulness of the technology. However, analysis revealed larger main effects of perceived ease of use + usability on attitudes toward using (F [33, 65] = 4.373, p<.001, partial η2 = .689) and perceived usefulness (F [33, 65] = 2.585, p<.001, partial η2 = .568), which were both significant per Wilks' Lamba =.169, F (33, 65) = 2.782, p<.001, partial η2 = .589). According to the adjusted R-squared, perceived ease of use + usability (PEUU) explained 53% of the variance in teachers' attitudes toward using and 35% of the variance in their perceived usefulness of the technology. Combined with perceived usefulness, perceived ease of use explained 63% and perceived ease of use + usability explained 77% of the variance in attitudes toward using. As perceived ease of use + usability has a slightly stronger main effect (influence) than perceived ease of use, Hypothesis 1, which states PEUU is more influential to the TAM than PEU, is fully supported.

Interestingly, teachers' perceived usability most highly correlated to their affective responses (attitude toward using the technology). This can lead us to the assumption that users' cognitive perceptions of a system's usability will significantly affect their affective responses toward the system, and other affective responses, such as mood and emotion, may play a part in the technology acceptance process. Although not hypothesized in this paper, perceived ease of use + usability, perceived usefulness, and attitudes toward using combined explained 73% of the variance in teachers' usage behavior. These findings support the importance of perceived usability in the evaluation of technology acceptance and usage behavior.

Hypothesis 2 results. Hypothesis 2 addressed whether technology self-efficacy will be more influential to the TAM than computer self-efficacy. Consequently, we evaluated the main effects of CSE and TSE on perceived ease of use and

Table 8. GLM Analysis Results for Perceived Ease of Use and Perceived Ease of Use + Usability

	Dependent Variable	Type III Sum of Squares	*df*	Mean Square	*F*	Sig.	Partial Eta Squared
Perceived Ease of Use							
Corrected Model	AT	1239.061	24	51.628	5.459	.000	.639
	PU	2264.273	24	94.345	2.987	.000	.492
Intercept	AT	42780.571	1	42780.571	4523.497	.000	.984
	PU	55982.671	1	55982.671	1772.374	.000	.960
Perceived Ease of Use	AT	1239.061	24	51.628	5.459	.000	.639
	PU	2264.273	24	94.345	2.987	.000	.492
Error	AT	699.848	74	9.457			
	PU	2337.383	74	31.586			
Total	AT	93212.000	99				
	PU	127492.000	99				
Corrected Total	AT	1938.909	98				
	PU	4601.657	98				
Perceived Ease of Use + Usability							
Corrected Model	AT	1336.834	33	40.510	4.373	.000	.689
	PU	2611.526	33	79.137	2.585	.001	.568
Intercept	AT	50213.580	1	50213.580	5421.057	.000	.988
	PU	67770.832	1	67770.832	2213.475	.000	.971
Perceived Ease of Use + Usability (PEUU)	AT	1336.834	33	40.510	4.373	.000	.689
	PU	2611.526	33	79.137	2.585	.001	.568
Error	AT	602.075	65	9.263			
	PU	1990.131	65	30.617			
Total	AT	93212.000	99				
	PU	127492.000	99				
Corrected Total	AT	1938.909	98				
	PU	4601.657	98				

perceived ease of use + usability. According to Pearson's correlations presented in Table 7, the relationship between TSE and PEU (r=.438, p<.000) was significantly stronger than the relationship between CSE and PEU (r=.238, p<.000). Furthermore, the relationship between TSE and PEUU (r=.518, p<.000) was significantly stronger than the relationship between CSE and PEUU (r=.247, p<.000). The reliability of the technology self-efficacy scale (α=.929) was also slightly higher than the computer self-efficacy scale (α=.916). Table 9 and Figure 4 present the results of the GLM analysis for testing Hypothesis 2.

Although the results in Table 9 indicate that computer self-efficacy has large main effects to perceived ease of use and perceived ease of use + usability, the multivariate tests (Wilks' Lamba = .267, F [43, 55] = 1.174, p=2.14, partial η2 = .483) shows that these effects are not significant. Thus, in this study, computer self-efficacy did not have a direct influence on PEU

Table 9. Computer and Technology Self-Efficacies GLM Results

Source	Dependent Variable	Type III Sum of Squares	*df*	Mean Square	*F*	Sig.	Partial Eta Squared
Computer Self-Efficacy							
Corrected Model	PEU	2569.583	43	59.758	1.622	.045	.559
	PEUU	5623.121	43	130.770	1.601	.050	.556
Intercept	PEU	118782.758	1	118782.758	3224.489	.000	.983
	PEUU	293227.973	1	293227.973	3589.578	.000	.985
CSE	PEU	2569.583	43	59.758	1.622	.045	.559
	PEUU	5623.121	43	130.770	1.601	.050	.556
Error	PEU	2026.074	55	36.838			
	PEUU	4492.879	55	81.689			
Total	PEU	169134.000	99				
	PEUU	415620.000	99				
Corrected Total	PEU	4595.657	98				
	PEUU	10116.000	98				
Technology Self-Efficacy							
Corrected Model	PEU	2672.198	47	56.855	1.508	.076	.581
	PEUU	6188.958	47	131.680	1.710	.031	.612
Intercept	PEU	112149.531	1	112149.531	2973.616	.000	.983
	PEUU	276499.364	1	276499.364	3590.863	.000	.986
TSE	PEU	2672.198	47	56.855	1.508	.076	.581
	PEUU	6188.958	47	131.680	1.710	.031	.612
Error	PEU	1923.458	51	37.715			
	PEUU	3927.042	51	77.001			
Total	PEU	169134.000	99				
	PEUU	415620.000	99				
Corrected Total	PEU	4595.657	98				
	PEUU	10116.000	98				

or PEUU. This is contrary to the findings of Venkatesh (2000), who found a significant impact of CSE on PEU. Unlike this study, which focuses on usage behavior, he focused on users' behavioral intention to use a new system. Technology self-efficacy is the same as computer self-efficacy, except it focuses on the ability to perform tasks on the specific technology the participant identified rather than computers in general. Although Venkatesh (2000) concluded that computer self-efficacy will directly influence perceived ease of use both before and after system usage, perhaps computer general perceptions, such as CSE, may be more influential for predicting intentions to use than usage behavior .

The effect of technology self-efficacy on perceived ease of use was not significant; however, the analysis revealed a main effect of TSE on perceived ease of use +usability (F [47, 51] = 1.710, p<.05, partial η2 = .612), which

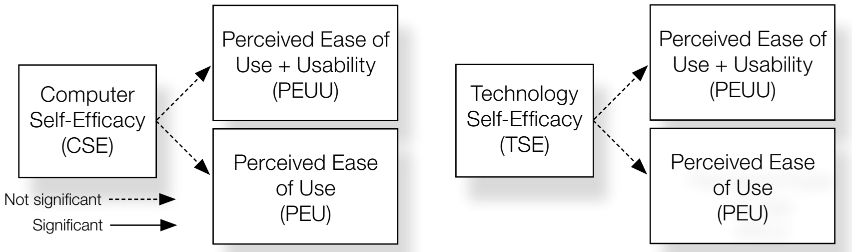

Figure 4. Main effects of computer and technology self-efficacies.

was significant per Wilks' Lamba =.157, F (47, 51) = 1.618, p<.05, partial η2 = .603). As presented in Figure 4, the effect of computer self-efficacy on PEU and PEUU are not significant; however, technology self-efficacy had a significant direct effect on perceived ease of use + usability, but not on perceived ease of use. According to the adjusted R-squared, technology self-efficacy explained 25% and computer self-efficacy (though not significant) explained 21% of the variance in perceived ease of use +usability. Although not hypothesized, both self-efficacies (users' subjective, cognitive beliefs) directly affected teachers' affective responses (attitudes toward using the technology), thus supporting the importance of the relationship between cognitive and affective responses in predicting users' technology acceptance.

Hypothesis 2, which states that technology self-efficacy is more influential to the TAM than computer self-efficacy, is supported with caution. Research has posed the expectation of computer self-efficacy to also directly influence PEU and PEUU, which did not occur in this evaluation. Venkatesh (2000) evaluated users' behavioral intentions to use of various technologies. His findings suggest that "the initial drivers of system-specific perceived ease of use are largely individual difference variables and situational characteristics, whose effect becomes stronger with experience." Unlike Venkatesh (2000), this study evaluated teachers' technology acceptance of various technologies they are already using. Thus, if individual differences in variables' influences are supposed to become stronger with use, it might make sense for teachers' technology-specific general perceptions to be more directly influential to perceived ease of use than their general perceptions toward computers. Clearly, teachers have distinguishable differences in their views of technology and computers. Perhaps when teachers self-assess their acceptance and usage behavior of technology, it is necessary that they have a specific technology in mind, especially when answering the questions relating to external variables, such as self-efficacy, anxiety, and playfulness. Holden (2009) found that technology self-efficacy, anxiety, and playfulness directly influenced technology acceptance more than computer self-efficacy, anxiety, and playfulness (Holden, 2009). Teachers' technology self-efficacy in this study had a higher influence on teachers' technology acceptance than their computer self-efficacy. In essence, the influence of computer and technology-specific perceptions, such as self-efficacy, might vary across different populations and technologies.

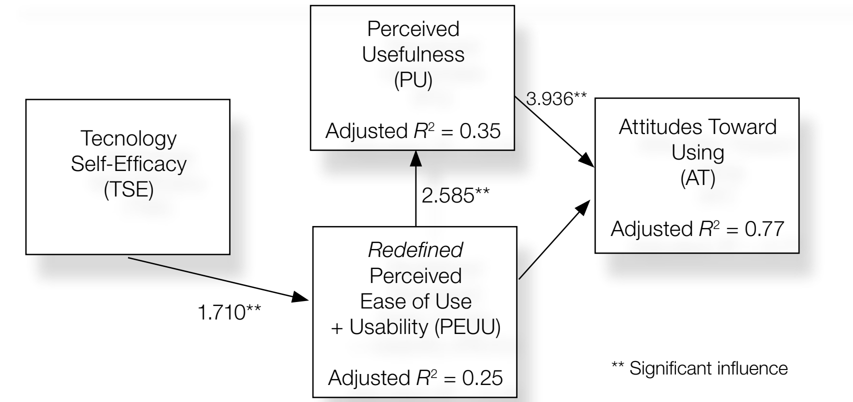

Figure 5. Research model results.

Figure 5 presents the overall results model of this research. We did not compute the arrow from TSE in the adjusted *R*-squared results of PU or AT, as it represents a user's individual external characteristic, which will most likely change for different evaluations.

Conclusions

Previous TAM studies have focused on various user populations and technologies. Some studies observe the acceptance and use of one specific technology, whereas others focus on a type of technology (i.e., Web applications, educational technologies, etc.). Whereas some studies focus on validating the original TAM on different populations and technologies, others focus on extending the TAM to evaluate the impact of external variables on acceptance and usage. In general, they all suggest that perceived ease of use significantly influences perceived usefulness, and both perceived usefulness and ease of use significantly influence attitudes toward using or behavior intention to use. Additionally, they find that attitudes toward using or behavioral intention to use significantly influence actual technology usage or usage behavior. In some studies the attitudes toward using and/or the usage behavior are eliminated altogether. This study did not consider the behavioral intention to use element, as we focused on the usage behavior of currently used technologies.

Summary

This paper addresses two research questions. First, we considered the influence of perceived usability on teachers' technology acceptance. Second, we addressed the influence of teachers' technology self-efficacy on their technology acceptance. In sum, this research extends the currently accepted TAM by incorporating usability and contributes to our understanding of how and why teachers are using the available technologies.

The first research question sought to evaluate the influence of usability on teachers' technology acceptance. This question relates to the benefit of incorporating additional perceived usability measures into the perceived ease of use construct. Many software development companies do not have instructional design processes and evaluation procedures including teachers and/or students prior to distribution (Higgins et al., 2000; Mills, 2001; Sugar, 2001; Williams et al., 2004). Teachers are concerned about whether the design of educational software actually meets the instructional requirements for flexibility and attention to individual needs (Hinostroza & Mellar, 1993; Shiratuddin & Landoni, 2002), yet the amount of supported literature on the usability of educational software remains scarce (Williams et al., 2004). Proper usability of a given technology may aid in reducing teachers' frustrations. Therefore, examining the perceived usability of technologies was an important segment of this study.

The need to explain more of the variance in the TAM suggests that the original perceived ease of use does not fully explain its targeted concept. The redefined perceived ease of use (perceived ease of use + usability) construct was more functional than the original perceived ease of use construct. This redefined construct is population independent and generalizable and will most likely yield similar results in future studies. The redefined perceived ease of use construct supports the importance, positive influence, and necessity of evaluating usability when investigating technology acceptance and usage behavior.

The second research question related to the impact of teachers' technology and computer self-efficacies other than their technology acceptance. Unlike the results of Venkatesh's (2000) study, computer self-efficacy did not significantly influence perceived ease of use in this study. However, technology self-efficacy did directly influence perceived ease of use and usability. The difference in the influences of self-efficacy between existing studies and this study is puzzling yet interesting. An important finding in this study suggests that the outcomes of these variables are population-dependent and possibly situation-based and will vary based on the targeted user population evaluated. Venkatesh (2000) found differences in the influences of external variables across populations. Additionally, Hubona and Burton-Jones (2005) found significant differences in the effects of individual difference variables across different technologies. Thus, the influences of external variables might not be generalizable and may vary depending on the population. This idea may be the reason why external variables have not been well investigated in many existing TAM studies. Nonetheless, they remain an important component in explaining the technology acceptance and usage behavior of the population in question.

Limitations of Study

This study has five limitations that may introduce biases. The first limitation relates to the technologies evaluated. This study used the proposed model to evaluate different technologies rather than one technology or technology in general. However, most existing studies use the TAM to measure one technology at a time. In this study, we assumed that by evaluating different educational technologies, we can make generalizations about educational technologies. Evaluating these different technologies can create undesired variance in the dependent variables. A future study should measure only one technology or a category of technologies and not different technologies on the same sample for the one evaluation.

The second limitation relates to the data collection method. The survey measures subjective, self-reported usage rather than objectively measured usage. Subjective, self-reported usage means teachers identify the technology they address, and this may introduce selection biases. If teachers were assigned technologies to discuss, such measures would be more objective. The original intention was to investigate why teachers are not using the identified technologies; however, the survey would have been too long. As a result, this study assumes no biases exist between teachers who are and are not using technologies.

The third limitation relates to the data analysis. This study uses general linear modeling instead of structural equation modeling, which is the most common data analysis technique used in most existing TAM studies. Structural equation modeling is not suitable when the underling variables are categorical and nonmetric (ordinal) data. Because the data of this study were nonmetric and observed simultaneous impacts, general linear modeling was the best approach. General linear modeling is a flexible statistical model that incorporates normally distributed dependent variables and categorical or continuous independent variables. However, the use of general linear modeling as a limitation in this study contributes to the lack of official evidence that general linear modeling is a better approach than structural equation modeling in TAM research. It might have added value to this study to use both data analysis techniques for the hypotheses testing.

The fourth limitation is common to all TAM studies and relates to the objective of the study. The data analysis shows only the variables that influence other variables and how strongly those influences are. It does not explain why these influences exist.

The last limitation pertains to the age of the TAM research papers that formulated this study. These papers were dated between the years 1989 and 2005, as preparation of this study began in 2006; however, more recent TAM studies might have addressed some of the concerns presented in this paper.

Implications

This study contributes to the field of evaluating users' technology acceptance and usage behavior by providing three implications for future researchers. First, future researchers should strongly consider evaluating the impact of technology self-efficacy on acceptance and usage behavior of different populations and different technologies. Several studies support the importance of external variables on technology acceptance and usage, although the influences of these variables vary depending on the populations and evaluated technologies. Thus, future researchers should be motivated to examine different populations' external variables more closely. Identifying these variables is beneficial for understanding user issues and identifying ways to improve the evaluated technology. Furthermore, by incorporating additional usability metrics into the proposed model, researchers can identify where users have problems with the evaluated technology and what areas need to be improved to increase acceptance and usage.

Second, future researchers should also consider using the redefined perceived ease of use construct on different technologies and populations. The impact of this redefined construct should be generalized to other situations. Last, future studies should consider creating simulations and modeling techniques to mimic users' responses. Simulations and modeling can be useful for identifying the reactions of the research model when changes in influences are introduced. For example, if technology self-efficacy is a significant influence on perceived ease of use and is increased (for example, by training), modeling this change would show how perceived ease of use has improved.

Moreover, this research contributes to the field by helping technology designers, researchers, and school districts. Technology designers and human–computer interaction researchers typically focus on user interface design and usability to enhance user acceptance. Although this research agrees with these focal points, our results suggests that other important factors, such as the external variables, that are not directly related to human–technology interactions that influence users' acceptances of technology. These system-independent factors should be considered early in the designing and development phases and incorporated into end-user training methods (Venkatesh, 2000). Thus, technology designers and researchers should also focus on these system-independent factors in conjunction with human–computer interaction methods. This can ultimately lead to better methods of effectively combining technology acceptance and human–computer interaction techniques to positively influence usage behavior. Additionally, TAM researchers should consider using the redefined perceived ease of use (PEUU) construct on different technologies and populations for further evaluation. Future research is needed to support technology designers when developing potential technologies.

School districts can use the research model to help calculate the return on their investments of educational and instructional technologies. Typically, school districts purchase various technologies and present them to (and possibly train) their teachers. However, they rarely conduct evaluations of the use of these technologies after implementation. Using the research model can give school districts the opportunity to understand whether their technologies are being adequately or underutilized among their teachers. This model is different from other technology usage surveys because it shows the particular aspects of the technology that are a problem.

Additionally, school districts might increase teachers' acceptance and use of current technologies by focusing on increasing the influential individual external factors, such as self-efficacy. For example, in this study, teachers' technology self-efficacy toward the evaluated technologies was directly influential to their acceptance of such technologies. By increasing their technology self-efficacy, they might directly increase their acceptance and indirectly increase their usage behavior. Possible methods include training catered to increasing teachers' general perceptions of the specific technology or creating an environment where teachers can collaborate about their experiences with the technology. This research could be also useful for school districts contemplating investment of new technologies. In sum, this study begins to bridge the gap between technology acceptance and usability research and evaluations. Closing this gap can help researchers and technology developers better understand what users want in their future technologies, thereby potentially increasing technology usage worldwide.

Acknowledgments

The authors would like offer our sincere appreciation and gratitude to the public school districts of Accomack County and King William County in Virginia for their support and participation in this research.

Author Notes

Heather Holden earned her PhD in information systems in 2009 from the University of Maryland Baltimore County (UMBC) with a dissertation titled "Assessing Teacher's Acceptance and Usage Behavior of Current Job-Related Technologies." She has published exploratory versions of her thesis work, but this manuscript represents the only definitive effort to convey the essence of her thesis results in journal format. She is currently conducting research in various areas of artificial intelligence, education, and training. Please address correspondence regarding this article to Heather Holden, Dept. IS, UMBC, Baltimore, MD 21250. E-mail: hholden1@umbc.edu

Roy Rada is a professor of information systems at UMBC and was the mentor for Dr. Holden's PhD thesis. He has authored approximately 200 journal articles and 20 books and has done research on educational technology during the past 30 years. He was co-editor for many years of the journal Interactive Learning Environments and has served on several other educational technology editorial boards. Please address correspondence regarding this article to Roy Rada, Dept IS, UMBC, Baltimore, MD 21250. E-mail: rada@umbc.edu

References

Alavi, M., & Joachimsthaler, E. A. (1992). Revisiting DSS implementation research: A meta-analysis of the literature and suggestions for researchers. *MIS Quarterly, 16*(1), 95–116.

Albion, P. R. (2001). Some factors in the development of self-efficacy beliefs for computer use among teacher education students. *Journal of Technology and Teacher Education, 9*(3), 321–347.

Bandura, A. (1986). *Social functions of thought and action: A social cognitive theory.* Upper Saddle River, NJ: Prentice-Hall.

Bitner, N., & Bitner, J. (2002). Integrating technology into the classroom: Eight keys to success. *Journal of Technology and Teacher Education, 10*, 95–100.

Burton-Jones, A., & Hubona, G. (2005). Individual differences and usage behavior: Revisiting a Technology Acceptance Model assumption. *ACM SIGMIS Database, 36*(2), 58–77.

Chen, N.-S., Huang, H.-Y., & Shih, Y.-C. (2002). Factors affecting usage of Web-based teachers' training in elementary and high school. In Kinshuk, R. Lewis, K. Akahori, R. Kemp, T. Okamoto, L. Henderson, & C.-H. Lee (Eds), *Proceedings of the International Conference on Computers in Education* (pp. 589–592). Washington DC: IEEE Computing Society Press.

Compeau, D. R., & Higgings, C. A. (1995). Application of social cognitive theory to training for computer skills. *Information Systems Research, 6*(2), 118–143.

Czerniak, C., Lumpe, A., Haney, J., & Beck, J. (1999). Teachers' beliefs about using educational technology in the science classroom. *International Journal of Educational Technology, 1*(2), np. Retrieved from http://ascilite.org.au/ajet/ijet/v1n2/czerniak/

Davis, F. (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology. *MIS Quarterly, 13*(3), 319–339.

Davis, F. D. (1993). User acceptance of information technology: System characteristics, user perceptions, and behavioral impacts. *International Journal of Man-Machine Studies, 38*, 475–487.

Delcourt, M., & Kinzie, M. (1993). Computer technologies in teacher education: The measurement of attitudes and self-efficacy. *Journal of Research and Development in Education, 27*(1), 35-41.

Dillon, A. (Ed.) (2001). User acceptance of information technology. In W. Karwowski (Ed.), *Encyclopedia of human factors and ergonomics* (pp. 1–10). London, UK: Taylor and Francis.

Downey, J. (2006). Measuring general computer self-efficacy: The surprising comparison of three instruments in predicting performance, attitudes, and usage. In R. Sprague (Ed.), *Proceedings of the 39th Hawaii International Conference on System Sciences* (Vol. 8, pp. 210–220). Washington DC: IEEE Computing Society Press.

Grandon, E., Alshare, O., & Kwan, O. (2005). Factors influencing student intention to adopt online classes: A cross-cultural study. *Journal of Computing Sciences in Colleges, 20*(4), 46–56.

Higgins, K., Boone, R., & Williams, D. (2000). A framework for the evaluation of educational software in special education. *Intervention in School & Clinic, 36*(2), 109–115.

Hinostroza, J. E., & Mellar, H. (1993). Pedagogy embedded in educational software design: Report of a case study. *Computers & Education, 37*, 27–40.

Holden, H. (2009). *Assessing teachers' acceptance and usage behavior of current job-related technologies.* Unpublished Dissertation, University of Maryland Baltimore, County, Baltimore, MD. UMI # 3389007.

Hu, P. J., Clark, T. H., & Ma, W. W. (2003). Examining technology acceptance by school teachers: A longitudinal study. *Information & Management, 41*, 227–241.

Hubona, G., & Burton-Jones, A. (2002). Modeling user acceptance of e-mail. In R. Sprague (Ed.), *Proceedings of the 35th Hawaii International Conference of System Sciences* (Vol. 1, pp. 25–35). Washington, DC: IEEE Computing Society Press.

Hubona, G., & Geitz, S. (1997). External variables, beliefs, attitudes, and information technology usage behavior. In R. Sprague (Ed.), *Proceedings of the 30th Annual Hawaii International Conference on System Sciences* (Vol. 3, pp. 21–28). Washington, DC: IEEE Computing Society Press.

Hubona, G., & Kennick, E. (1996). The impact of external variables on information technology usage behavior. In R. Sprague (Ed.), *Proceedings of the 29th Annual Hawai'i International Conference on System Sciences* (Vol. 4, pp. 166–176). Washington, DC: IEEE Computing Society Press.

Jimoyiannis, A., & Komis, V. (2007). Examining teachers' beliefs about ICT in education: Implications of a teacher preparation programme. *Teacher Development, 11*(2), 149-173.

Lai, M.-L. (2008). Technology readiness, Internet self-efficacy and computing experience of professional accounting students. *Campus-Wide Information Systems, 25*(1), 18–29.

Ma, Q., & Liu, L. (2007). The role of Internet self-efficacy in accepting Web-based medical records. In M. Mahmood (Ed.), *Contemporary issues in end user computing* (pp. 54–76). Hershey, PA: IGI Global Publishing.

Ma, W. W.-K., Andersson, R., & Streith, K.-O. (2005). Examining user acceptance of computer technology: An empirical study of student teachers. *Journal of Computer Assisted Learning, 21*, 387–395.

Maurer, H. (1997). Necessary ingredients of integrated network-based learning environments. In T. Muldner & T. Reeves, (Eds), *Proceedings of EdMedia 1997* (pp. 709–716). Chesapeake, VA: Association for the Advancement of Computing in Education.

Mills, R. J. (2001). Analyzing instructional software using a computer-tracking system. *Information Technology, Learning, and Performance Journal, 10*(1), 21–30.

Pajares, M. F. (1992). Teachers' beliefs and educational research: Cleaning up a messy construct. *Review of Educational Research, 62*, 307–332.

Park, S. Y. (2009). An analysis of the Technology Acceptance Model in understanding university students' behavioral intention to use e-learning. *Educational Technology & Society, 12*(3), 150–162.

Preece, J. (1994). *Human-computer interaction*. Boston, MA, USA: Addison-Wesley Publishing Company.

Preece, J., & Rodgers, H. (2002). *Interaction design beyond human-computer interaction*. New York: John Wiley & Sons, Inc.

Shiratuddin, N., & Landoni, M. (2002). Evaluation of content activities in children's educational software. *Evaluation and Program Planning, 25,* 175–182.

Strong, D. M., DiShaw, M., & Brady, D. B. (2006). Extending task technology fit with computer self-efficacy. *ACM SIGMIS, 37*(2–3), 96–107.

Sugar, W. A. (2001). What is so good about user-centered design? Documenting the effect of usability sessions on novice software designers. *Journal of Research on Computing in Education, 33*(3), 235–250.

Szajna, B. (1996). Empirical evaluation of the revised technology acceptance model. *Management Science, 42*(1), 85–92.

Turoff, M. (1995). *Designing a virtual classroom.* Paper presented at the International Conference on Computer-Assisted Instruction, Hsinchu, Taiwan. Retrieved from http://www.shss.montclair.edu/useful/design.html

Venkatesh, V. (2000). Determinants of perceived ease of use: Integrating control, and emotion into the Technology Acceptance Model. *Information Systems Research, 11*(4), 343–365.

Venkatesh, V., & Davis, F. D. (1996). A model of the antecedents of perceived ease of use: Development and test. *Decision Sciences, 27*, 451–481.

Venkatesh, V., & Davis, F. D. (2000). A theoretical extension of the Technology Acceptance Model: Four longitudinal field studies. *Management Science, 46*(2), 186–204

Wade, V., & Lyng, M. (2000). An automated evaluation service for educational courseware. In G. Davies, & C. Owen (Eds.), *WebNet 2000 World Conference on WWW and Internet proceedings* (pp. 569–574). Chesapeake, VA: Association for the Advancement of Computing in Education.

Williams, D., Boone, R., & Kingsley, K. (2004). Teachers beliefs about educational software: A delphi study. *Journal of Research on Technology in Education, 36*(3), 213–229.