Predicting User Intentions: Comparing the Technology Acceptance Model with the Theory of Planned Behavior

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Information systems (IS) cannot be effective unless they are used. However, people sometimes do not use systems that could potentially increase their performance. This study compares two models that predict an individual's intention to use an IS: the technology acceptance model (TAM) and the theory of planned behavior (TPB). The comparison was designed to be as fair as possible, not favoring one model over the other. Both TAM and TPB predicted intention to use an IS quite well, with TAM having a slight empirical advantage. TAM is easier to apply, but only supplies very general information on users' opinions about a system. TPB provides more specific information that can better guide development.

User behavior—User acceptance—User attitudes—Laboratory experiment

1. Introduction

Information systems (IS) have the potential to improve organizational performance, but only if they are actually used. Although firms require that certain systems be used for some tasks, in other cases system use is voluntary. The more these systems are used, the greater the impact they can have (Trice and Treacy 1988). People are sometimes unwilling to use systems, however, even if the IS could increase their job performance (Nickerson 1981).

Since systems that are not used cannot be effective, no matter what their technical merits, it is important to understand how people decide whether they will use a particular IS. The issues that influence this decision are likely to vary with the system, the individual, and the context. If these issues can be identified, developers can take them into account during system design.

Note that the emphasis is on IS *use*, not the IS itself. An individual might feel that a system could help improve decision making, but not use it because of lack of convenient access to a terminal, lack of time, etc. Research in social psychology shows that behavior is best predicted by an individual's attitude towards the behavior (such as using an IS), rather than his or her attitude towards objects involved in the behavior (such as the IS) (Fishbein and Ajzen 1975). A positive evaluation of an IS may be a necessary but not always sufficient condition for system use.

Developers employ a number of techniques to ensure that users will accept the systems they build. User participation in design is seen as a key to achieving acceptance. Although the empirical evidence is mixed (Barki and Hartwick 1989), many believe that systems developed with user participation will better match user

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requirements and capabilities than systems designed solely by IS professionals. In some system development methodologies (e.g., Naumann and Jenkins 1982; Gane 1989), a small group of users participate heavily in systems specification and logical design. However, this approach may be effective only if the users participating in the design are representative of the final user base. When a system is designed to serve a large number of people, perhaps the development team should ensure that an IS acceptable to the team is also acceptable to the broad spectrum of users.

During development, it is difficult to estimate eventual system use, since the system does not yet exist. An individual's intention to use the system can be measured, however. There is considerable evidence that intention to perform a behavior predicts actual behavior (Sheppard, Hartwick, and Warshaw 1988).

Measuring user acceptance is important not only during design or immediately after implementation. Over time, there will be changes in the system, the users, and the environment in which both operate (Swanson 1988). The business environment might change, affecting users' information requirements. Changes made to satisfy one group of users may make the system less suitable for other purposes. Users' expectations might change as they become more familiar with IS technology, and what was once acceptable may no longer be adequate (Doll and Ahmed 1983).

This study compares two models that predict an individual's intention to use an IS. The first is the technology acceptance model (TAM), specifically designed by Davis (1986) to predict use of an IS. The second is the theory of planned behavior (TPB), discussed by Ajzen (1985, 1989). TPB was designed to predict behavior across many settings, and can be applied to IS use.

The models are compared on three criteria. First, how well do they predict the user's intention to use an IS? If one model predicts intention much better than another, it can provide a more accurate picture of the issues that developers should consider in addressing system acceptability. Answering this question requires a fair empirical comparison, that is, a comparison that is not biased in favor of one model or the other. Second, how valuable is the information provided by the models? If the models do not supply information that can guide development, they will not be useful to systems analysts, no matter how well they predict intention. Third, how difficult are the models to apply? Ideally, the models would provide valuable information at a low cost. Answers to these questions will help decide, first, whether the models are useful at all, and, second, the conditions under which one might be more useful than the other.

The paper proceeds as follows. First, TAM and TPB are described, and the differences between them examined. The conditions necessary for a fair comparison, identified by Cooper and Richardson (1986), are reviewed. Second, an empirical study, designed to compare the extent to which the models predict intention to use a system, is described. Its results are then presented. Finally, the limitations of the study and the implications of its findings are discussed.

2. The Models

2.1. *The Technology Acceptance Model*

TAM:

> . . . is specifically meant to explain computer usage behavior. . . . (p. 983) The goal of TAM is to [be] . . . capable of explaining user behavior across a broad range of end-user computing technologies and user populations, while at the same time being both parsimonious and theoretically justified. (p. 985).
>
> (Davis, Bagozzi, and Warshaw 1989)

Figure 1 shows the model. Ease of use (EOU) is "the degree to which the . . . user expects the target system to be free of effort" (Davis et al. 1989, p. 985). Usefulness

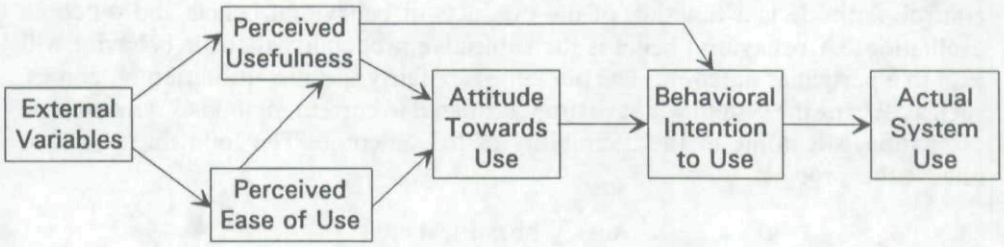

FIGURE 1. The Technology Acceptance Model.

(U) is the user's "subjective probability that using a specific application system will increase his or her job performance within an organizational context" (p. 985). U is influenced by EOU. Both EOU and U predict attitude (A), defined as the user's evaluation of the desirability of his or her using the system. A and U influence the individual's intention to use the system (I). Actual use of the system is predicted by I.

TAM is fairly new, and has not been extensively tested. The empirical tests that have been conducted suggest it predicts intention fairly well. Davis et al. (1989) found that TAM successfully predicted use of a word processing package. Davis (1989) reports that EOU and U were significantly correlated with use of an office automation package, a text editor, and two graphics packages.

2.2. *The Theory of Planned Behavior*

TPB is outlined in Figure 2. Behavior is determined by intention (I) to perform the behavior. Intention is predicted by three factors: attitude toward the behavior (A), subjective norms (SN), and perceived behavioral control (PBC). Both A and I are defined as for TAM. SN is the individual's perception of social pressure to perform the behavior. PBC is the individual's perception of his or her control over performance of the behavior.

Beliefs are antecedent to attitude, subjective norms, and perceived behavioral

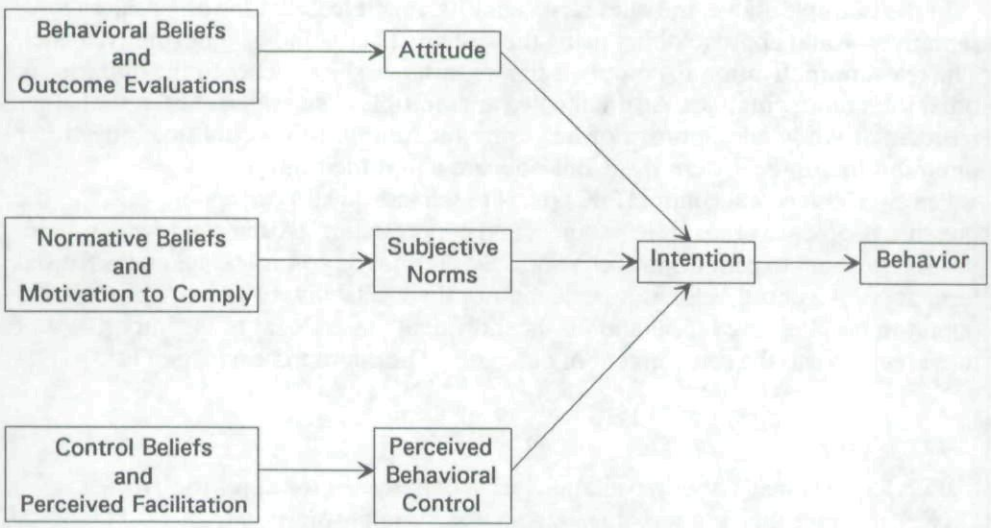

FIGURE 2. The Theory of Planned Behavior.

control. Attitude is a function of the products of behavioral beliefs and outcome evaluations. A behavioral belief is the subjective probability that the behavior will lead to a particular outcome. The outcomes are fairly specific, utilitarian outcomes, such as "Using the system will save time compared to current methods." An outcome evaluation is a rating of the desirability of the outcome. The following equation reflects this process:

$$A = \sum_{i=1}^{n_b} bb_i oe_i \quad \text{where}$$

bb_i = behavioral belief i,
oe_i = outcome evaluation of belief i,
n_b = number of salient outcomes.

As an example, suppose a sales representative is considering using a laptop PC to access a central database on product availability. A potential outcome from using the system is improved customer service. The relevant behavioral belief is the extent to which she believes using the system will improve customer service. The associated outcome evaluation would be the importance of improving customer service. Because behavioral beliefs and outcome evaluations are multiplied, they would have the greatest impact on attitude if *both* (1) the sales representative felt that the system would improve customer service, *and* (2) improving customer service is important.

Subjective norms reflect the perceived opinions of referent others. A "referent other" is a person or group whose beliefs may be important to the individual. A normative belief is the individual's perception of a referent other's opinion about the individual's performance of the behavior. Motivation to comply is the extent to which the person wants to comply with the wishes of the referent other. In equation form:

$$SN = \sum_{i=1}^{n_o} nb_i mc_i \quad \text{where}$$

nb_i = normative belief about referent other i,
mc_i = motivation to comply with referent other i,
n_o = number of salient others.

In the example above, the sales representative might feel that the other sales representatives would approve of her using the system. This would be a normative belief. The relevant motivation to comply is the importance she attaches to the opinions of other sales representatives. Again, the two are multiplied, so even if she felt that other representatives would approve of her using the laptop, this would not impact her intention to use the system if she did not care about their opinions.

Perceived behavioral control (PBC) refers to the individual's perceptions of ". . . the presence or absence of requisite resources and opportunities" (Ajzen and Madden 1986, p. 457) necessary to perform the behavior. PBC depends on control beliefs and perceived facilitation. A control belief is a perception of the availability of skills, resources, and opportunities. Perceived facilitation is the individual's assessment of the importance of those resources to the achievement of outcomes. The appropriate equation is:

$$PBC = \sum_{i=1}^{n_c} cb_i pf_i \quad \text{where}$$

cb_i = control belief about availability of skill, resource, or opportunity i,
pf_i = perceived facilitation of skill, resource, or opportunity i,
n_c = number of salient skills, resources, or opportunities.

Control beliefs can be situational (e.g., having access to a terminal) as well as personal (e.g., being able to use a system). PBC goes beyond TAM's ease of use (EOU) construct to embrace other barriers to system use. Suppose that the laptop PC in the example above requires access to a telephone to contact a central mainframe. The sales representative often visits building sites, where there is no telephone available. Her control belief about the availability of a telephone (one of the resources required to perform the behavior) would be low. However, she might rate the perceived facilitation of telephone availability as high. That is, telephone access is important, but it is often not available.

Overall, the sales representative might not be inclined to use the system. Although the behavior (system use) might achieve a valuable outcome (improved customer service), there would be little social benefit, and she does not have easy access to all of the necessary resources.

The weights in the equations (oe_i, mc_i, and pf_i) can be measured in two ways. First, the individual can be asked to specify them using, for example, a Likert scale (direct assessment). Second, the weights can be estimated as coefficients in regression equations (indirect assessment). Direct assessment is useful when subjects disagree about the sign of a weight (Fishbein and Ajzen 1975, p. 238). However:

> When the evaluative polarity of an outcome is fairly homogeneous across subjects, the corresponding belief tends to be monotonically related to attitudes, and statistically estimated weights tend to accurately capture the actual usage of information cues . . . and generally predict dependent variables as well as subjective weights. . . .
>
> Davis et al. (1989, p. 988)

Both approaches are compared below for the IS-use case.

Since the theory of planned behavior (TPB) is fairly new, there have been relatively few empirical tests of its effectiveness. Schifter and Ajzen (1985) successfully applied TPB to the prediction of weight loss behavior. Ajzen and Madden (1986) used TPB to predict students' decisions about attending class and earning a good grade.

There have been more tests of the theory of reasoned action (TRA), on which TPB is based. The main difference between the models is that TRA does not consider perceived behavioral control. It predicts behavior solely from attitudes and subjective norms, and is predictive in those situations where there are no significant barriers to behavioral performance (Fishbein and Ajzen 1975). Sheppard et al. (1988) report a meta-analysis of 87 studies from which they concluded that there is "strong support for the overall predictive utility of the Fishbein and Ajzen [TRA] model" (p. 336). In the computing domain, Yeaman (1988) found that TRA predicted intention to learn to use a microcomputer, although subjective norms did not contribute to the prediction. Davis et al. (1989) reported that TRA predicted intention to use a word processing program, although, again, subjective norms did not contribute to the explained variance.

2.3. *Differences Between the Models*

There are three main differences between TAM and TPB. The first is their varying degree of generality. The second is that TAM does not explicitly include any social variables. The third is that the models treat behavioral control differently. Each of these points is discussed below.

2.3.1. *Degree of Generality.* TAM assumes that beliefs about usefulness and ease of use are always the primary determinants of use decisions. This was a conscious choice on the part of Davis et al. (1989), since they wanted to use "a belief set that . . . readily generalizes to different computer systems and user populations" (p. 988). TPB uses beliefs that are specific to each situation. The model does not assume that beliefs that apply in one context also apply in other contexts. Although some beliefs may generalize across contexts, others may not.

This difference between the models raises three concerns. First, in some situations there could be variables besides ease of use and usefulness that predict intention. For example, accessibility might be an important factor for users who are not always near a terminal. Identifying such beliefs is part of the standard methodology for using TPB. While such exploration is not excluded from TAM, it is not an essential part of the model.

Second, TPB is more difficult to apply across diverse user contexts than TAM. TAM's constructs are measured in the same way in every situation. TPB requires a pilot study to identify relevant outcomes, referent groups, and control variables in every context in which it is used. This can be complex if different user groups focus on different outcomes from use of the same system. For example, students using a computer-aided learning system might be interested in maximizing exam scores, while instructors are interested in saving class time. Ideally, TPB's instruments would be tailored to each group.

Third, some TPB items require an explicit behavioral alternative if they are to be as specific as possible. For example, in asking someone whether using a spreadsheet for sales forecasting will save time (a behavioral belief), it is best to explicitly identify an alternative behavior so that the basis for comparison is clear. Potential users might be asked to respond to the following item: "Using a spreadsheet instead of a calculator will save me time in developing sales forecasts. (Agree/Disagree)." TAM does not require the identification of a specific comparison behavior. The advantage of TPB's approach is that all respondents are making the same comparison. The comparison target is not specified in TAM's instruments, and may vary across subjects (Ryan and Bock 1990). The disadvantage of TPB's approach is that this reference point may not apply to all individuals. For example, some people may be generating sales forecasts using a specialized DSS instead of a calculator, so the question may not provide a useful comparison to current practices.

2.3.2. *Social Variables.* The second major difference between TAM and TPB is that TAM does not explicitly include any social variables. These are important if they capture variance that is not already explained by other variables in the model. Davis et al. (1989) point out that social norms are not independent of outcomes. For example, an individual might perceive pressure from his or her supervisor to use a system, with an implied outcome of nonuse being a poor performance evaluation. That is, social norms will already have been taken into account to some extent in the evaluation of outcomes.

However, the social variables in TPB may still capture unique variance in intention. There could be social effects that are not directly linked to job-related outcomes such as usefulness. For example, some individuals might use a system because they think they will be perceived by their coworkers as technologically sophisticated. This motivation is more likely to be captured by TPB than by TAM.

2.3.3. *Behavioral Control.* The third major difference between TAM and TPB is their treatment of behavioral control, referring to the skills, opportunities, and resources needed to use the system. The only such variable included in TAM is ease of use (EOU). Examining the EOU items used by Davis (1989, p. 340), it is apparent that EOU refers to the match between the respondent's capabilities and the skills required by the system. The items include "Learning to operate [the system] would be easy for me," and "My interaction with [the system] would be clear and understandable."

Although possession of requisite skills is important, sometimes other control issues will arise. Ajzen (1985) differentiates between internal control factors that are characteristics of the individual, and external factors that depend on the situation. Internal factors include skill and will power. External control factors include time, opportunity, and the cooperation of others. For instance, where connect time and CPU usage are charged to user departments, some people might not have the resources necessary to use a system, even if they feel they could benefit from doing so and have the necessary skills. In other words, they are denied the opportunity to use the system by external factors.

EOU corresponds to the internal factor of skill. However, external control issues are not considered in TAM in any obvious way. Although it could be argued that the EOU item "I would find [the system] easy to use" (from Davis 1989) implies that respondents consider external control issues, this is not explicit.

Some control factors will be stable across situations, while others will vary from context to context (Ajzen 1985). An individual takes the same skills from situation to situation, and to the extent that similar skills are required for different IS-related tasks, ability should be a fairly stable control factor. In fact, Hill, Smith, and Mann (1987) found that a general efficacy measure predicted intentions to use a wide range of technologically advanced products. However, some control issues will be idiosyncratic to particular circumstances. For example, while the availability of a telephone line was important to the sales representative, it will not be important to other people in other situations.

TPB taps the important control variables for each situation independently, and is more likely to capture such situation-specific factors. TAM is less likely to identify idiosyncratic barriers to use. This is in keeping with the stated objective of Davis et al. (1989) to develop a model that is applicable across many situations, but will cause the model to miss control issues that are important in particular contexts.

2.4. *Ensuring a Fair Comparison*

A study comparing two models should not be biased in favor of one or the other. Cooper and Richardson (1986) maintain that a fair comparison possesses (a) procedural equivalence, and (b) distributional equivalence. A procedurally equivalent test provides equally careful measures of each theory's constructs and "equivalent fidelity to the boundary conditions for each of the competing theories" (p. 179). Distributional equivalence requires that "the factors or variables [being assessed] vary over equivalent ranges of values in their respective populations" (p. 179).

The first condition for procedural equivalence is that the boundary conditions of both theories be observed. The most important difference in boundary conditions is that TPB is more specific. Dimensions of specificity include action, target, context, and time (Ajzen and Fishbein 1980, p. 34). In this study, a group of relatively

homogeneous subjects indicated their intention to use (action) either a particular spreadsheet or a calculator (target) to solve a specific problem (context) within a certain period (time). The situation is specific enough for TPB and also respects the broader boundary conditions of TAM.

Second, equal attention should be given to measurement. Attitude and intention have the same definitions in both TAM and TPB, so the same measures were used. TAM's ease of use (EOU) and usefulness (U) variables were measured using instruments developed by Davis (1989). TPB's measures were constructed using the procedures recommended for TRA in Ajzen and Fishbein (1980), extended to include the control variables. Ajzen and Madden (1986) used the same approach. For both TAM and TPB, the measurement procedures developed by the theories' authors were adopted.

Distributional equivalence is more difficult to establish, since it requires knowledge of population variances. These are not known, so distributional equivalence is not guaranteed. Two suggestions can be made, however. First, subjects in this study were sampled from the same population, and were randomly assigned to either the TAM or TPB groups. Since the same measures for intention and attitude were used for both TAM and TPB, these variables should possess distributional equivalence. There should be no large differences in means or standard deviations across the groups. This can be tested empirically. Second, the standard deviations of those variables that are not common to both models (such as TAM's usefulness and TPB's belief variables) can be examined for obvious cases of range restriction.

An important aspect of this study is that both models were tested in the same context, using subjects sampled from the same population, facing the same usage decision about the same types of systems. Because of this commonality, observed differences between the models are likely to be due to the models themselves, rather than differences in the contexts in which they were used.

3. Methodology

3.1. *Subjects, Setting and Procedure*

The subjects were juniors and seniors in an introductory management course at a western university. They received class credit for participation. There were 163 males and 99 females in the sample. Their average age was 22.3 years. They had taken an average of 10.9 college semester credit hours of computer-related courses. The task is shown in Appendix 1. It can be completed using either a spreadsheet or a calculator. Subjects were free to choose either solution method.

A pilot study was conducted to identify salient beliefs for the TPB conditions, using the procedure discussed in Ajzen and Fishbein (1980). A group of 18 students, none of whom were in the main sample, participated. They were given a copy of the task, and responded to the open-ended questions shown in Appendix 2. They were also asked to identify the spreadsheet package with which they were most familiar.

For outcome- and control-related issues, only beliefs mentioned by at least 50% of the subjects were retained. The relevant outcome beliefs were: (1) time taken to complete the assignment and (2) solution accuracy. These are similar to beliefs elicited by Davis et al. (1989). The control beliefs were: (1) knowledge of use of the spreadsheet, (2) access to the spreadsheet, and (3) portability of the spreadsheet. The 50% criterion was not reached for any referent other, so the three most frequently mentioned referents were included. The referent groups were: instructors in courses other than the one in which the assignment was given (mentioned by 7 subjects),

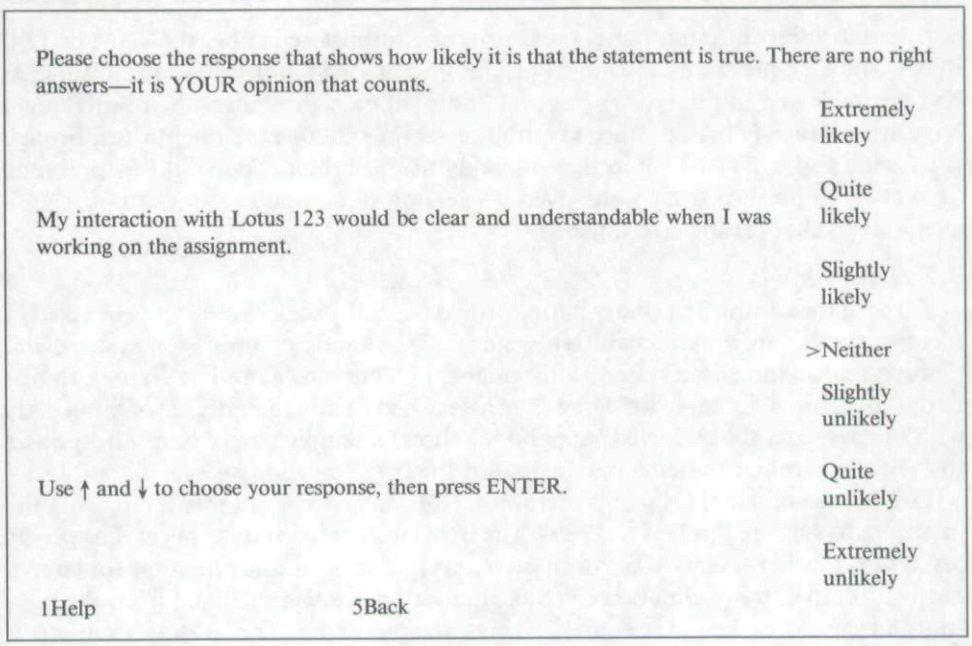

FIGURE 3. Sample Computer Screen Showing a TAM Ease of Use Item. The subject had selected Lotus 123 as the spreadsheet he or she used most often.

employers (mentioned by 4), and other students (mentioned by 5). Some subjects mentioned the instructor of the course in which the assignment was given. However, to emphasize that spreadsheet use was completely voluntary, this referent was not used.

Data for the main study were gathered using two computer programs developed by the author. Figure 3 shows a sample screen. One program administered TAM's instruments while the other administered TPB's instruments. Subjects reported to one of a number of sessions held in a computer laboratory. They selected a PC, which randomly chose whether it would run the TAM or TPB program. The researcher did not know which program the computer would run. Each subject ran only one of the programs, to avoid contamination across instruments. The TAM program was used by 149 subjects and the TPB program by 113 subjects.

The programs first administered a computing ability questionnaire adapted from Cheney and Nelson (1988). The questionnaire served two purposes. First, it contained a disguised validity instrument, designed to improve data quality by eliminating subjects who either (1) did not pay attention to the items or (2) did not respond honestly. The items are described later. Second, the ability questionnaire identified the spreadsheet each subject used most frequently. The list of packages was developed from the pilot study responses. The spreadsheet each subject selected was mentioned by name in all of the appropriate items, as shown in Figure 3. This had the advantages of (1) increasing the specificity of the items, by keeping subjects focused on a particular package, and (2) maximizing the amount of information subjects had about the package mentioned in the items, by focusing on the package with which each subject was most familiar. The disadvantage is that subjects responded to items about different spreadsheet packages. Differences in responses across packages were controlled statistically, as discussed later.

After the ability questionnaire, the programs administered either the TAM or TPB items. The TPB program took longer to run, since it asked more questions. If subjects had been allowed to leave when they had finished their programs, the results might have systematically biased, since (1) subjects seeing others leave might rush through the items, and (2) TAM subjects were likely to finish first. To avoid this problem, subjects who finished early were given a selection of computer games to play until everyone in that session had finished.

3.2. *Instruments*

Three of the computing ability items formed a validity scale. Subjects were asked to identity the (1) network recognition system, (2) dynamic compression system, and (3) hierarchical transition system with which they were most familiar. To the author's knowledge, these do not exist. They were also asked to rate their degree of familiarity with the packages they selected. Appendix 3 shows a sample pair of items. Responses to the three familiarity items were averaged to obtain a validity score.

TAM's ease of use (EOU) and usefulness (U) constructs were measured using the instruments reported in Davis (1989). The items were framed in terms of the specific task. TPB's belief (behavioral, normative, and control) and evaluation (outcome, motivation to comply, and perceived facilitation) items were derived from the pilot study discussed earlier. Appendix 3 shows sample items. The attitude, subjective norms, perceived behavioral control, and intention instruments are shown in Appendix 3. The attitude and intention instruments were common to TAM and TPB.

4. Results

This section presents the results of the study. First, the use of the validity scores and the instruments' interitem reliabilities are discussed. Second, the distributional equivalence of the samples is considered. Third, differences between responses relative to different spreadsheets are examined. Fourth, the extent to which TAM and TPB explain intention is discussed. Finally, the differences between assessed and estimated weights for TPB are considered.

4.1. *Validity Scale and Instrument Reliabilities*

Analysis of the validity scale showed that most subjects were honest about their abilities. Only 15 subjects listed their skills as higher than 'Low' on the nonexistent systems. Those subjects were dropped, leaving 247 in the sample. Table 1 shows the interitem reliabilities for each multi-item instrument, calculated using Cronbach's alpha. All of the values are acceptable.

4.2. *Distributional Equivalence*

Tables 2 and 3 give descriptive statistics for the TAM and TPB groups. There is no difference in mean attitude ($t = 0.666$, df = 245, $p > 0.05$ two-tailed) or intention ($t = 1.485$, df = 245, $p > 0.05$ two-tailed) between the groups. There is also no difference in the variance of intention ($F = 1.108$, $u_1 = 138$, $u_2 = 107$, $p > 0.05$ two-tailed). However, the variance of attitude for TAM is slightly higher than the variance for TPB ($F = 1.533$, $u_1 = 138$, $u_2 = 107$, $p < 0.05$ two-tailed). The difference between is small, however, and is unlikely to strongly bias the results.

There are no obvious restrictions in range or variance for the TAM variables. For some TPB variables, however, one end of the variable's range is within one standard deviation of its mean. The variables are OE Accuracy, NB Employers, MC Employers, PF Knowledge, PF Access, and CB Portability. As discussed later, only NB Employers and CB Portability were used in analyses that would be affected by this

TABLE 1
Instrument Reliabilities (Cronbach's Alpha)

TAM

Measure	Alpha
EOU	0.938
U	0.902
A	0.923
I	0.966

TPB

Measure	Alpha
A	0.804
SN	0.864
PBC	0.791
I	0.932

problem. Estimates of the true effects of these two variables may be biased downward (Cooper and Richardson 1986, p. 179).

4.3. *Differences Between Spreadsheets*

For both TAM and TPB, a family of regressions was used to test for differences in responses across spreadsheets. Most subjects chose one of three spreadsheets: Lotus 123 (123 subjects), Framework (54), and Quattro (44). Twenty-six subjects chose one of four other systems (such as Multiplan); they were not used for this analysis. A modified Bonferonni test was used for both models with a family significance level of 0.15 (see Cohen and Cohen 1983, p. 167).

For TAM, four regressions were run, the independent variables being ease of use (EOU), usefulness (U), attitude (A), and intention (I). Two effects-coded independent variables were used in each regression equation to represent the spreadsheet being used, following the procedure suggested by Cohen and Cohen (1983, p. 198). None of the regressions was significant. The spreadsheet package chosen did not affect responses to any TAM variables.

For TPB, regressions were run only for those variables that would theoretically be expected to be influenced by spreadsheet choice. If analyses had been conducted for all variables, the single-equation significance level would have been unreachable, guaranteeing that differences would not have been detected. Only the following

TABLE 2
Descriptive Statistics for TAM
n = 139

Variable	Mean	Standard Deviation
EOU	5.084	1.255
U	5.277	1.208
Attitude	5.362	1.321
Intention	4.772	1.824

TABLE 3
Descriptive Statistics for TPB
n = 108

Variable	Mean	Standard Deviation
BB Time	3.833	1.847
OE Time	5.278	1.213
BB Accuracy	4.731	1.197
OE Accuracy	6.574	0.800
NB Instructors	5.417	1.086
MC Instructors	4.990	1.431
NB Employers	6.167	0.870
MC Employers	5.926	1.108
NB Students	4.731	0.963
MC Students	3.852	1.393
CB Knowledge	3.444	1.475
PF Knowledge	6.324	0.841
CB Access	3.047	1.436
PF Access	6.185	0.949
CB Portability	1.630	1.090
PF Portability	4.287	1.535
Attitude	5.466	1.067
SN	4.969	1.028
PBC	3.772	1.266
Intention	4.432	1.733

variables were analyzed: the two behavioral beliefs, the three control beliefs, attitude, perceived behavioral control, and intention. All of the items measuring these variables referred to specific spreadsheets by name. Only attitude was significantly affected by spreadsheet type, with mean attitude towards using Framework (4.75) being lower than mean attitude towards using Lotus 123 (5.67) or Quattro (5.73). This difference was statistically controlled in the analyses discussed below.

4.4. *Explaining Intention*

Table 4 shows how well TAM fits the data. The table gives the variance explained and regression weights for each equation in the model. Ease of use (EOU) explains a significant amount of the variance in usefulness (U). EOU and U contribute to attitude (A). A and U contribute to intention (I). Given the usual size of correlation coefficients in behavioral research (Organ 1988, p. 49), the multiple correlation coefficients are quite large. TAM is successful in explaining intention. The pattern of results is similar to that observed by Davis et al. (1989) and Davis (1989), with intention being affected more by usefulness than by attitude, and attitude being affected more by usefulness than by ease of use. The variance explained by TAM in this study was higher than that explained in Davis et al. (1989), and higher than most of the explained variances in Davis (1989).

Table 5 shows the equivalent results for TPB. The independent variables are the behavioral, normative and control beliefs, without the corresponding weights. The effects of spreadsheet type were controlled for those analyses involving attitude. Two dummy variables were introduced into the equations to represent which of the three commonly-used spreadsheets each subject chose. Seven subjects used one of the less common spreadsheets; these observations were excluded from the analysis.

TABLE 4
TAM's Fit to the Data
n = 139

	β	R^2	Shrunken R^2
U = EOU	0.667	0.446	0.442
A = EOU + U	0.218	0.731	0.727
	0.694		
I = A + U	0.389	0.697	0.693
	0.481		

Again, the variance explained by the model is comparatively large. Intention was predicted by attitude and PBC, but not by SN. This suggests that social pressures did not influence individual's decisions to use a spreadsheet. Attitude had a slightly stronger effect on intention than PBC.

Recall that some of TPB's variables suffered from range restrictions. As mentioned earlier, most of the variables with a restricted range were assessments of weights, and were not used in estimating TPB's fit to the data. The only two variables that were used in Table 5 were NB Employers and CB Portability. Thus, the amount of variance explained in subjective norms (SN) and perceived behavioral control (PBC) may be slightly under-estimated.

Turning to a comparison of TAM and TPB, it appears that TAM explains attitude much better than TPB. Part of the difference in the explained variance in attitude (0.727 for TAM and 0.388 for TPB) may be due to the fact that there was more variance in attitude for TAM (1.745) than for TPB (1.138). However, this fairly small discrepancy is unlikely to account for all of the difference in explained variance. Notice that both models predict intention well, although TAM explains slightly more variance than TPB.

4.5. *Assessed Versus Estimated Weights*

The weights in TPB's equations (outcome evaluations, motivations to comply, and perceived facilitations) can be measured in two ways, both of which were used in this

TABLE 5
TPB's Fit to the Data

	β	R^2	Shrunken R^2	n
A = Time	0.297	0.412	0.388	101*
+ Accuracy	0.380			
SN = Instructors	0.191	0.477	0.462	108
+ Employers	0.376			
+ Students	0.383			
PBC = Knowledge	0.555	0.520	0.506	108
+ Access	0.290			
+ Portability	NS			
I = A + SN + PBC	0.493	0.621	0.601	101*
	NS			
	0.410			

* = see text.

study. First, they were assessed directly by asking subjects to respond to questionnaire items shown in Appendix 3. The mean responses to these items are shown in Table 3. These are the assessed weights. Second, the weights were estimated using regression equations. The standardized regression coefficients shown in Table 5 are the estimated weights.

According to both the assessed and estimated weights, accuracy (OE Accuracy) is a more important outcome than time saved (OE Time). The weights for the control issues also show the same pattern for both assessed and measured weights, with knowledge of use (PF Knowledge) being more important than access (PF Access), and both being more important than portability (PF Portability). The main difference between the estimated and assessed weights is in motivation to comply with students (MC Students). Tables 3 and 5 both show that the opinions of other instructors (MC Instructors) are weighted less than those of employers (MC Employers). However, while subjects said that the opinions of other students were the least important of all of the groups, the estimated weights suggest that the opinions of other students are more important than those of any other group. In fact, students usually attach some importance to the opinions of their peers (Dalton 1987). This suggests that the estimated weights may be more accurate than the assessed weights.

5. Discussion

5.1. *Limitations of the Study*

The study has some potential limitations. First, although intention to use a system was measured, the relationship between intention and behavior was not. This is not a serious problem. First, TAM and TPB both predict behavior from intention. Given that this study's objective was to compare the models, it is not necessary to examine relationships that are the same across models. Second, there is substantial empirical support for the intention-behavior link. For TAM, both Davis et al. (1989) and Davis (1989) show that the intention is related to behavior. Ajzen and Madden (1986) found a similar result for TPB. The theory of reasoned action (TRA), on which both TAM and TPB are based, includes the same intention-behavior link. Sheppard et al. (1988) reported a correlation of 0.53 between intention and behavior for TRA in their extensive meta-analysis. Given these results, the fact that behavior was not directly assessed is not a serious limitation.

The second potential limitation is the sample and the task. Many different IS are used in a wide variety of settings by many different people. No single task with a single group of users can fully represent this diversity, regardless of whether the subjects are students, insurance agents, secretaries, or sales managers, and regardless of whether the task is financial forecasting, risk estimation, scheduling meetings, or sales forecasting (Ryan and Bock 1990).

Limitations in the sampling of tasks, subjects, and contexts may explain the lack of significance of subjective norms in this study, in Davis et al. (1989), and in Yeaman (1988). All three used student subjects in university environments. In other situations, subjective norms may influence intention. Robertson (1989) presents some evidence that social demands influence system use. An objective for future research would be to identify the conditions under which subjective norms are important. TPB provides some guidance here, suggesting that both the perceived opinions of others and motivation to comply with those opinions should be considered. However, TPB's handling of social issues is relatively poor, as suggested by Davis et al.

(1989). Perhaps a different framework, such as social network theory (used by Robertson 1989), would prove more fruitful.

The third problem is with distributional equivalence. An effort was made to make the tests of the models as comparable as possible by randomly sampling from the same population of subjects. However, the range of some of TPB's variables was restricted, affecting the variance explained in subjective norms and perceived behavioral control. Intention to use an IS was not affected by this problem, however.

5.2. *Conclusions*

In the introduction, three criteria were suggested for comparing the models. The first was their ability to predict intention to use a system. Clearly, both the technology acceptance model (TAM) and the theory of planned behavior (TPB) explain intention quite well. Although TAM explained more variance than TPB, the difference is not large enough to conclude that one model is better than the other on purely empirical grounds. Note, however, that TAM explained attitude towards using an IS much better than TPB, and may be the model of choice when this variable is of particular interest.

The second criterion was the value of the information provided by the models. TAM supplies very general information about ease of use and usefulness. TPB delivers more specific information, measuring the system's performance on various outcomes, and identifies factors that respondents feel might be barriers to system use. It also identifies groups whose opinions might be important to potential users.

The information TPB furnishes is probably more useful during development and post-implementation evaluation than the information TAM provides. TPB can focus development efforts on specific problems. For example, while TAM might show that respondents feel that a system is marginally useful, TPB would show which of a set of outcomes was not being achieved. TAM would tell developers that a system was not easy to use, but would not identify other issues that might prevent system use. Further, although the validity of TPB's approach to social pressures is in question, the information could be valuable if it identifies possible sources of resistance.

The third criterion was the cost of using the models. TAM is easier to use than TPB. Davis (1989) has developed standard instruments for TAM, while measures of TPB's beliefs need to be developed for each context. This usually involves a pilot study in which users are asked about relevant outcomes, social influences, and control issues.

This discussion provides some guidelines for choosing between the models. Given that both models are empirically strong, the choice depends on the other two criteria. TAM provides a quick and inexpensive way to gather general information about individuals' perceptions of a system. It can be used to measure general levels of satisfaction across a range of users with diverse interests. TPB delivers more specific information, giving more insight into why an individual or group might be dissatisfied. However, it is more costly to apply.

Both models could be used together very effectively. Suppose a system had been built to serve users in several different functional areas. An analyst could use TAM to identify dissatisfied users and discover the general nature of their complaints. TAM is ideally suited to this purpose, since (1) it is inexpensive to apply and (2) TAM's general constructs (usefulness and ease of use) are probably meaningful to most people, no matter what their functional area. Once a group of particularly dissatisfied

users had been identified, TPB could provide more detailed information that might be specific to the group. In other words, the general and inexpensive information TAM provides could identify areas where it would be desirable to have the more specific and expensive information TPB provides.

In sum, this study compared the technology acceptance model and the theory of planned behavior. Considerable attention was given to making the comparison as unbiased as possible. Both models provided good predictions of individuals' intentions to use an IS, although TAM slightly outperformed TPB. TAM is easier to use, while TPB provides more information about the factors users consider when making their choices.*

* Blake Ives, Associate Editor. This paper was received on July 31, 1990 and has been with the author $3\frac{1}{2}$ months for 2 revisions.

Appendix 1. The Task

You are given the following assignment:

You work for MortCorp., an insecticide manufacturer. You are asked to forecast sales, costs and profit for the next 4 years. The finance officer supplies you with information on sales and cost trends, as well as information about planned expenditures, as follows:

1. Sales in 1989 were $2.5m.
2. Sales are expected to grow by 6% for 1990 and 1991 and by 4% in 1992 and 1993.
3. Direct costs are expected to remain at 43% of sales for 1990 and 1991. In the beginning of 1992, a new mixing machine (still under development) will be installed. It will cost $900,000 and reduce direct costs to 32% of sales. The full cost of the machine will be allocated in 1992.
4. Overhead was $0.8m in 1989 and is expected to grow at its historical rate of 5% per year.
5. Taxes are 25% of gross profit.

Given this information, do the following:

A. Fill in the following table (all figures are in millions):

	Year			
	1990	1991	1992	1993
Sales	$2.65	?	?	?
less Direct Costs	$1.14	?	?	?
less Overhead	$0.84	?	?	?
less Equipment	—	—	$0.90	—
Goss profit	$0.67	?	?	?
less Taxes	$0.17	?	?	?
Net profit	$0.50	?	?	?

B. How would the table change if sales grew by only 3% in 1992 and 1993?

C. How would the table change if the new machine reduced direct costs to 36% of sales instead of the expected 32%?

The assignment is given near the beginning of the semester. Its objective is just to remind you of some accounting basics. It is the ONLY problem of this nature you will receive during the semester. There will be NO other computational assignments.

You have 2 weeks to do the assignment. You can use either your calculator or a spreadsheet. The choice is up to you. Your choice will NOT affect your grade in any way. The assignment does not have to be typed. As long as the answers are correct, it does not matter whether they come from a spreadsheet or from a calculator.

Appendix 2. Questions Used in the Pilot Study

The same questions were asked separately about using a spreadsheet package and a calculator.

What are the advantages for a typical student in using a (spreadsheet package/calculator) to solve the problem?

What are the disadvantages for a typical student in using a (spreadsheet package/calculator) to solve the problem?

Is there anything else you associate with a typical student using a (spreadsheet package/calculator) to solve the problem?

Who would approve of a typical student using a (spreadsheet package/calculator) to solve the problem?

Who would disapprove of a typical student using a (spreadsheet package/calculator) to solve the problem?

What other people come to mind when you think about a typical student using a (spreadsheet package/calculator) to solve the problem?

What factors would prevent a typical student using a (spreadsheet package/calculator) to solve the problem?

Appendix 3. Items

Fully-anchored 7-point Likert scales were used for all items. For brevity, only the endpoints are shown.

In all of the items, "[the spreadsheet]" refers to the spreadsheet package subjects stated they used most often.

Validity (Sample)

Screen 1:

Which network recognition system do you use most frequently? Please choose one from this list. If you are not familiar with any, choose one at random and choose "very low" on the next screen.

NRW
NetRec II
SuperNet
DynaNet

Screen 2:

My ability to use the package I chose on the last screen is (Very high/Very low).

Behavioral Belief (Sample)

It would take me (Much more/Much less) time to do the assignment with [the spreadsheet] than to do the assignment with my calculator.

Outcome Evaluation (Sample)

How important is it to you that you get the assignment done quickly? (Very important/Very unimportant)

Normative Belief (Sample)

Instructors in other courses would (Strongly support/Strongly oppose) my using [the spreadsheet] rather than my calculator for the assignment.

Motivation to Comply (Sample)

Think about instructors in classes other than this one. They might have an opinion about which tool you should use for the assignment (either [the spreadsheet] or your calculator). How important would their opinion be to you when you were choosing a tool for the assignment? (Very important/Very unimportant)

"Important" means that their opinion is something you would take into account when making your decision. "Unimportant" means that their opinions would not influence your decision.

Control Belief (Sample)

I would know how to use [the spreadsheet] FOR THE ASSIGNMENT (Much better/Much worse) than I would know how to use my calculator.

Spreadsheets and calculators have many sophisticated features that you would not need for the assignment. This question only concerns the functions that you would need to complete the assignment. When you are answering the question, please think ONLY about the features of spreadsheets and calculators that are relevant to the assignment. For example, the graphical functions of a spreadsheet would not be important, and the statistical functions of a calculator would not be important.

Perceived Facilitation (Sample)

How important would it be that you knew enough about how to use the tool you choose (either [the spreadsheet] or your calculator) so that you could complete the assignment? (Very important/Very unimportant)

Attitude Items

1. I think it would be (Very good/Very bad) to use [the spreadsheet] rather than my calculator for the assignment.
2. In my opinion it would be (Very desirable/Very undesirable) to use [the spreadsheet] rather than my calculator for the assignment.
3. It would be (Much better/Much worse) for me to use [the spreadsheet] rather than my calculator for the assignment.

Subjective Norm Items

1. Those people who are important to me would (Strongly support/Strongly oppose) my using [the spreadsheet] rather than my calculator for the assignment.
2. I think that those people who are important to me would want me to use [the spreadsheet] rather than my calculator for the assignment. (Strongly agree/Strongly disagree)
3. People whose opinions I value would prefer me to use [the spreadsheet] rather than my calculator for the assignment. (Strongly agree/Strongly disagree)

Perceived Behavioral Control

1. I would have (Much more/Much less) control over using [the spreadsheet] for the assignment than over using my calculator.

"Control" refers to the freedom you feel you have to make a choice. For example, someone who does not own a bicycle or does not know how to ride one has less control over cycling to [a nearby town] than someone who does own one and does know how to ride it.

2. Given the resources, opportunities and knowledge it takes to use each tool ([the spreadsheet] and my calculator), it would be easier for me to choose [the spreadsheet] rather than my calculator for the assignment. (Strongly agree/Strongly disagree)
3. I would be (Much more/Much less) able to use [the spreadsheet] rather than my calculator for the assignment because of differences in the resources, opportunities and knowledge it takes to use each one.

Intention

1. I would use [the spreadsheet] rather than my calculator to do the assignment. (Strongly agree/Strongly disagree) Remember: your answers are anonymous. Please answer honestly.
2. My intention would be to use [the spreadsheet] rather than my calculator to do the assignment. (Strongly agree/Strongly disagree) Remember: your answers are anonymous. Please answer honestly.
3. To do the assignment, I would use [the spreadsheet] rather than my calculator. (Strongly agree/Strongly disagree) Remember: your answers are anonymous. Please answer honestly.

References

Ajzen, I., "From Intentions to Actions: A Theory of Planned Behavior," in J. Kuhl and J. Beckmann (Eds.), *Action Control: From Cognition to Behavior,* Springer Verlag, New York, 1985, 11–39.

Ajzen, I., "Attitude Structure and Behavior," in A. R. Pratkanis, S. J. Breckler, and A. G. Greenwald (Eds.), *Attitude Structure and Function,* Lawrence Erlbaum Associates, Hillsdale, NJ, 1989, 241–274.

———— and M. Fishbein, *Understanding Attitudes and Predicting Social Behavior,* Prentice-Hall, Inc., Englewood Cliffs, NJ, 1980.

———— and T. J. Madden, "Prediction of Goal-Directed Behavior: Attitudes, Intentions and Perceived Behavioral Control," *Journal of Experimental Social Psychology,* 22, (1986), 453–474.

Barki, H. and J. Hartwick, "Rethinking the Concept of User Involvement," *MIS Quarterly,* 13, 1 (1989), 53–63.

Cheney, P. H. and R. R. Nelson, "A Tool for Measuring and Analyzing End-User Computing Abilities," *Information Processing and Management,* 24, 2 (1988), 199–203.

Cohen, J. and P. Cohen, *Applied Multiple Regression/Correlation Analysis for the Behavioral Sciences,* Lawrence Erlbaum Associates, Hillsdale, NJ, 1983.

Cooper, W. H. and A. J. Richardson, "Unfair Comparisons," *Journal of Applied Psychology,* 71, 2 (1986), 179–184.

Dalton, J. C., "The Influence of Peer Culture on College Student Values," presented at the Annual Meeting of the American College Personnel Association, Chicago, IL, 1987.

Davis, F. D., "A Technology Acceptance Model for Empirically Testing New End-User Information Systems: Theory and Results," Doctoral Dissertation, Sloan School of Management, Massachusetts Institute of Technology, 1986.

————, "Perceived Usefulness, Perceived Ease of Use, and End User Acceptance of Information Technology," *MIS Quarterly,* 13 (1989), 318–339.

———, R. P. Bagozzi and P. R. Warshaw, "User Acceptance of Computer Technology: A Comparison of Two Theoretical Models," *Management Science,* 35 (1989), 982–1003.

Doll, W. J. and M. U. Ahmed, "Managing User Expectations," *Journal of Systems Management,* (June 1983), 6–11.

Fishbein, M. and I. Ajzen, *Belief, Attitude, Intention and Behavior: An Introduction to Theory and Research,* Addison-Wesley, Reading, MA, 1975.

Gane, C., *Rapid Systems Development,* Prentice-Hall, Englewood Cliffs, NJ, 1989.

Hill, T., N. D. Smith and M. F. Mann, "Role of Efficacy Expectations in Predicting the Decision to Use Advanced Technologies: The Case of Computers," *Journal of Applied Psychology,* 72, 2 (1987), 307–313.

Naumann, J. D. and A. M. Jenkins, "Prototyping: The New Paradigm for Systems Development," *MIS Quarterly,* 6, 3 (September 1982), 29–44.

Nickerson, R. S., "Why Interactive Computer Systems Are Sometimes Not Used by People Who Might Benefit from Them," *International Journal of Man-Machine Studies,* 15 (1981), 469–483.

Organ, D. W., *Organizational Citizenship Behavior: The Good Soldier Syndrome,* Lexington Books, Lexington, MA, 1988.

Robertson, D. C., "Social Determinants of Information System Use," *Journal of Management Information Systems,* 5, 4 (Spring 1989), 55–71.

Ryan, T. and D. B. Bock, "Comparability of Ratings in MIS Survey Research," presented at the Annual Meeting of the Decision Sciences Institute, San Diego, CA, 1990.

Schifter, D. B. and I. Ajzen, "Intention, Perceived Control and Weight Loss: An Application of the Theory of Planned Behavior," *Journal of Personality and Social Psychology,* 49 (1985), 843–851.

Sheppard, B. H., J. Hartwick and P. R. Warshaw, "The Theory of Reasoned Action: A Meta-Analysis of Past Research with Recommendations for Modifications and Future Research," *Journal of Consumer Research,* 15 (1988), 325–343.

Swanson, E. B., *Information System Implementation: Bridging the Gap Between Design and Utilization,* Irwin, Homewood, IL, 1988.

Trice, A. W. and M. E. Treacy, "Utilization as a Dependent Variable in MIS Research," *Data Base,* (Fall/Winter 1988), 33–41.

Yeaman, A. R. J., "Attitudes, Learning and Human-Computer Interaction: An Application of the Fishbein and Ajzen Model of Attitude-Behavior Consistency," *Proceedings of the Annual Meeting of the Association for Educational Communications and Technology,* New Orleans, LA, January 1988, 814–818.