Early Validation of Information System Prototypes Using the Technology Acceptance Model

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Abstract

This study applies the Technology Acceptance Model (TAM) to determine whether future users of an information system are able to accurately differentiate between "good" and "bad" prototypes. TAM has previously been used on completed systems. However, by the time a system is completed, development resources have already been expended and changes to the system are difficult and expensive. It would be beneficial to be able to assess intent to use the completed system early in the development cycle. A developer would determine probable system usage by having potential users of the system work with the prototype, then complete the TAM instrument.

Results of our study indicate that TAM can be used as a simple, low-cost determinant of a "bad" prototype, permitting improvements to be made continuously throughout the development cycle.

1. Introduction

It has long been recognized that even the most carefully designed information system (IS) can be rejected by end-users, resulting in a waste of the resources required to design and implement the system. The problem has been to identify the reasons the system has been rejected, and by extension, to identify those systems which have a high probability of rejection prior to committing substantial resources. Numerous authors have addressed this issue (e.g., Boehm, 1982; Alavi, 1984; Swanson, 1987). In this study, we combine two well-tested and widely-accepted techniques, prototyping and the Technology Acceptance Model, to identify systems which are likely to be rejected.

Prototyping is one of the foremost methods used to involve end-users in system development with the goal of increased user acceptance. Cheap and quickly-built, a prototype allows users to interact directly with a working model, in contrast to other methods (such as data flow and entity relationship diagrams, decision trees and
tables, and data dictionary reports) which require the user to visualize, rather than actually use, the system.

The Technology Acceptance Model (TAM) was derived by Davis (1986) from a general social psychology model, the Theory of Reasoned Action, which has been supported by many studies. TAM employs the constructs of "perceived usefulness" and "perceived ease of use" to determine user intent to utilize an information system. Studies by Davis (1986), Davis, Bagozzi, and Warshaw (1989), Mathieson (1991) and Davis (1989) have shown that TAM scores correlate significantly with actual usage of a system; therefore, the constructs of perceived usefulness and perceived ease of use are considered indicators of rejection or acceptance of a system.

If perceived usefulness and perceived ease of use are measured early in the development cycle, it will be possible to diagnose problem areas and take corrective action at that time when risk and expense are lower. Boehm (1982) discusses several points in regard to the desirability of correcting software deficiencies early. The cost of correction increases as the development process evolves through the traditional life-cycle stages. Particularly significant is that the portion of IS development expense attributable to software development ("people expense") is increasing as the price-performance ratio of hardware continues to improve. Our study experimentally examines whether perceived usefulness and perceived ease of use can accurately be determined from a prototype of a proposed IS.

2. Technology Acceptance Model

The Technology Acceptance Model (figure 1) is designed to predict IS usage based on a short period of initial contact. TAM also provides an explanatory framework as an aid in identifying reasons the system under consideration succeeds or fails to win acceptance by endusers (Davis, 1986; Davis, Bagozzi, and Warshaw, 1989). This predictive and explanatory information is valuable to system developers, enabling them to test early designs of the system prior to investing substantial resources.

When developing TAM, Davis chose the constructs of perceived usefulness and perceived ease of use because of the body of literature identifying them as determinants of attitudes towards, and usage of, information systems. Davis defined perceived usefulness as "the degree to which a person believes that using a particular system would enhance his or her job performance" and perceived ease of use as "the degree to which a person believes that using a particular system would be free of effort."

External variables enter the model through influence on perceived usefulness (U) and perceived ease of use (EOU). Here the model reflects the results of changes in design (e.g., a particular screen design may alter EOU). EOU affects A ("attitude
toward using") both directly, and indirectly through U. Similarly, U affects BI ("behavioral intention to use") directly, and indirectly through A. BI is a direct determinant of ASU ("actual system use"). The relationships between the variables are linear:

\[
(\text{ASU}) = -b_0(\text{BI})
\]

\[
(\text{BI}) = -b_1A + b_2U
\]

\[
A = -b_3U + b_4(\text{EOU})
\]

\[
U = -b_5(\text{EOU}) + b_6\{\text{func(external-variables)}\}
\]

\[
(\text{EOU}) = -b_7\{\text{func(external-variables)}\}.
\]

U and EOU are each measured by the responses to four items on a seven point Likert scale (likely Å unlikely). Refer to Davis (1986) for details of the general TAM instrument.

Further experimentation (Davis, Bagozzi, Warshaw, 1989; Davis, 1989) resulted in a refined "hybrid" TAM instrument, which we use in this study. This instrument measures U with eight items and EOU with 4 items. For this instrument, in the short run the most accurate model was (BI) = -b_0U + b_1(EOU), while after an extended period of use (BI) = -b_2U and U = -b_3(EOU) provided the best fit; the strength of the "usefulness Å intended usage" relationship was greater than the "ease of use Å intended usage" relationship. Davis et al. found that the Cronbach alpha was greater than 0.9 for the hybrid TAM instrument.

Figure not available. Please contact author.

Figure 2 depicts the relationship of prototyping, TAM, the end-user, and the system developer. The system developer implements a prototype based on a perception of the end-user's requirements. The end-user operates the prototype and provides the system developer two types of feedback: 1) verbal comments, and 2) a completed TAM survey. The system developer responds to the feedback and either alters the prototype or assumes user acceptance.

3. Research Questions

The purpose of this research is to use TAM to determine if perceived usefulness and perceived ease of use can be accurately measured from end-user interaction with a prototype in order to predict IS acceptance as early in the system development cycle as possible.

Given the assumptions that 1) prototyping is a valid way of providing an early analysis of a potential user's reactions to the system, and 2) TAM provides a valid
prediction of intent to accept the system, then TAM should be able to detect user likes and dislikes caused by the "goodness" of the prototype. Based on the results in Davis (1989) it is reasonable to expect that TAM will record more positive BI for an IS that is easy to use and satisfies user requirements rather than for an IS which is deficient in either or both of those characteristics. Furthermore, an IS deficient in only one characteristic will receive a more positive BI than an IS deficient in both. We further expect that there will be a higher correlation between U and BI than between EOU and BI.

4. Research Methodology

Subjects were exposed to an IS prototype and asked to evaluate it in terms of the likelihood of using the system to be developed from the prototype. The experimental design and components are described here.

A prototype (Model A) of an information system for a fictional college registrar's office was developed and made to completely match a given set of specifications (the usefulness construct Ä U). The prototype was also made easy to use (EOU). Three additional models were derived from Model A: Model B was less useful (did not meet all specifications) but retained the ease of use; Model C was made more difficult to use, but completely met all specifications; and Model D was both less useful and harder to use.

To validate that our choice of features made prototype A the "best" prototype and D the "worst", we ran two separate pilot studies on business professionals, one group from a merchandising establishment and the other from a communications company. These professionals all worked with information systems on a regular basis.

There were ten volunteers in the first pilot study. Each was given a disk which contained a program that presented the four prototypes in an order determined by a random number generator. The volunteer could use each prototype for any length of time. The program then asked that the prototypes be ranked in order of "preference", a term left purposely vague in line with the theory that whether a user "likes" or "dislikes" a system is based on personal perceptions. The results show that on average, users felt that prototype A was "best" and prototype D was "worst". In addition to the average figure, no user considered A to be least preferred, or D to be most preferred.

Subjects for the second pilot study were twenty-two employees from a local communications company. This group was asked to follow exactly the same methodological procedure as would be used for the student study. The preferences of this group were measured by behavioral intent (BI), i.e., the intent to use the system once completed. Results from this pilot also confirmed the researchers' judgment of prototype quality rank.
The subjects of the main study were 181 university business students. A mix of students was sought from various majors in order to accurately represent the diversity of backgrounds which would be expected in a business setting. All students had previously completed at least an introductory computer course, but beyond that computer knowledge and experience varied widely.

Subjects were given a written one-page description of a fictional college registrar system, including desired input and output, in advance of the experiment. A registration system was specifically chosen because of the familiarity university students have with classes, scheduling, and grades. The students were encouraged to study the description and become familiar with the IS requirements. Anonymity of responses was guaranteed to the subjects. Each subject was given a diskette which contained the four prototype models, the TAM instrument, and a master program which governed the operation of these components.

The master program first called a random number generator to select one of the four prototypes which the subject could operate as extensively as desired. When the subject finished testing the randomly selected prototype, the program administered the hybrid TAM instrument developed by Davis et al. (1989; see prior description).

5. Results

This section presents the results obtained from the study: the determination of whether users accurately judged the value of a prototype (and by extension, the finished system) by EOU and U. In the following analysis, an alpha value of 0.05 was chosen to indicate significance. We found TAM to be a highly reliable instrument, with a Cronbach's alpha of 0.93 for the perceived ease of use items and 0.96 for the perceived usefulness items, consistent with the findings reported in Davis, Bagozzi, and Warshaw (1989) and Davis (1989).

Comparison Among Prototype Quality Levels A series of pairwise comparisons was run to assess the differences in BI means between each pair of prototypes.

The tests indicated no difference in BI means between a prototype with high EOU and low U (model B) and one high in both features (model A); also no difference was shown for the comparison between low EOU and high U (model C) and high in both (model A). Therefore, it cannot be stated that a user is more likely to use a "perfect" prototype than a prototype low in one (but not both) of the constructs.

The mean BI for the prototype lacking in both EOU and U (model D) was significantly lower (p = .000) than the mean BI scores for prototypes lacking in only one characteristic (models B and C). That is, it is more likely that a user will use a prototype low in only one of the constructs than a prototype low in both.

Comparison of the BI means for the two prototypes high in one feature (EOU or U) but not the other (models B and C) indicate no significant difference. It cannot be
stated that a user is more likely to prefer a prototype deficient in one of the
customs over a prototype deficient in the other construct.

6. Discussion

The purpose of this study was an attempt to assess whether TAM could be used to
forecast future use of an IS based on initial exposure to a prototype of the IS. Our
expectation was that TAM might differentiate between the "perfect" prototype and
all others; results indicate instead that the differentiation is between the "worst"
prototype and all others. If this result is found to hold true in repeated studies, TAM
is then an easy, low-cost filter which will broadly separate "good" systems from
"bad" systems. Application of TAM at various stages of system development could
swiftly determine if, and when, an IS begins to deviate from the desired quality. If
the BI score is less than some desired value, further examination of the prototype
could be done to pinpoint specific shortcomings.

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