EXPLAINING SOFTWARE DEVELOPMENT TOOL USE WITH THE TECHNOLOGY ACCEPTANCE MODEL

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ABSTRACT

The increasing demand for information systems has driven the need for software developers to become more efficient and productive. In response, a wide variety of software development aids, such as new tools and techniques, have been introduced in an attempt to assist the development process. Unfortunately, the use of these software development innovations is not widespread, further exacerbating the problems in industry. Why are software development innovations, specifically software development tools, not used? To help answer the question, this study utilizes the popular Technology Acceptance Model (11). Consistent with prior studies, an exogenous variable, training, is added to the original TAM. Results from a study of one organization's early use of a custom-built software development tool (SDT) produced the following significant relationships: training → ease of use; ease of use → usefulness; and ease of use → usage. The insights provided from this study help to understand a software developer's use of SDTs.

INTRODUCTION

The importance of information systems in today's complex and dynamic environment only heightens the challenge of how to successfully develop information systems. Unfortunately, evidence suggests that software development is not improving, as it should. In addition to a growing two to four year application backlog (29), research indicates that only about 25% of all projects are successful (39). In an effort to improve software development, innovations ranging from CASE tools to prototyping to object-oriented development have been introduced in the recent past. However, subsequent research on these areas indicate that many of the tools such as CASE, techniques such as prototyping, and methodologies in general are not widely utilized (16, 17, 24). If these innovations are meant to improve software development, why are they not being used?

Toward answering this question, prior studies of software development innovations have investigated the acceptance of methodologies (e.g., 32, 33), techniques (e.g., 13, 25, 51), and CASE tools (e.g., 7, 21, 35) from a variety of perspectives (e.g., individual-level, organization-level analysis) and from many theoretical foundations. CASE tools, in particular, have received a large amount of interest due to their relative over-hype and under-use (7). This study is an extension to the line of research attempting to explain CASE tool use. Specifically, the current study applies one of the most widely used models of technology acceptance, the Technology Acceptance Mode (11), to the tool use question. In this case, the tool is not a CASE tool; rather, it is a custom-built tool created to assist developers in one particular organization. Training, as an exogenous variable, is added to the model, consistent with prior studies (e.g., 7, 20).

BACKGROUND

Theory

Use of an innovation is the end result of the adoption process: parties become aware of the innovation, the innovation is introduced, affected parties decide to adopt or reject the innovation, the innovation (if adopted) is used and on-going decisions are made regarding the continued use of the innovation. The entire process of awareness through use is often called the innovation process (34); some call it assimilation (13).

There are several streams of innovation research, including research about the innovation process and perceptions of using the innovation primarily based on the Diffusion of Innovations (DOI) (34), and intention-based models which use behavioral intention to predict usage based mainly on the Theory of Reasoned Action (TRA) (14) and its successor, the Theory of Planned Behavior (TPB) (3). The Technology Acceptance Model (11) based largely on the TRA, has gained widespread use in the field of information technology.

The TAM, originated by Davis, et al. (11) asserts that perceived usefulness and perceived ease of use (EOU) are the major determinants of intentions to use, and subsequent actual use of, information technology. It is expected that various external variables, such as training, user characteristics, and system characteristics, will affect EOU and usefulness (7).

The TAM has been tested many times and extended in a variety of ways. For example, the TAM (or close derivatives of it) has been successfully used to explain use of PCs in small businesses (20), intention to adopt group support systems (8), and use of popular software applications (1). Through all these studies, and many more, the TAM has proven to be a robust and parsimonious model for explaining IT use and intention to use.

Prior Research in Software Development Tool Use

As indicated earlier, much of the research in software development innovations has looked at CASE tool use. To provide perspective on the types of research in this area, overviews of some of the more recent studies are provided here. Using a combination of the TAM and Thompson, Higgins, and Howell's Model of PC Utilization (37), Chau (7) looked at individual-level CASE tool acceptance and found ease of use and long-term consequences to be direct determinants, and transitional support (i.e., training) and implementation gap to be antecedents to ease of use. In a study based largely on Moore and Benbasat's Perceived Characteristics of Innovating instrument (26), Iivari (21) examined CASE tool usage from both the organization and individual level of analysis.

Management support and voluntariness were significant from both perspectives, whereas compatibility was significant for individuals and relative advantage was important for organizations. Premkumar and Potter (30) looked at the influence of technology and organizational variables on an organization's decision to adopt CASE tools. Existence of a product champion, strong management support, lower IS expertise, relative advantage, and cost effectiveness were key discriminators between adopters and non-adopters. In contrast, Rai and Patnayakuni (31) did not find management support to be important in explaining an organization's adoption decision, but did find training, the product champion, and job/role rotation important. Orlikowski (28) and Dietrich, Walz, and Wynekoop (12) used a small set of case studies to examine CASE usage. Deitrich, et al. (12) found that although many companies purchased CASE tools, they were difficult to diffuse throughout the organization. In both cases, the researchers observed resulting organizational change from the adoption of the CASE tool, which may begin to explain initial (and continued) resistance to adoption and use. To provide measures of the breadth and depth of CASE tool usage, Sharma and Rai (35) used Henderson and Cooprider's (18) IS planning and design framework to compute two measures: adoption (proportion of development tasks for which CASE is used) and infusion (the extent of CASE use for development tasks).

Although CASE tools are usually the focus of software development innovations research, they represent only one of a myriad of tools that may be used to support software development. Program generators, data dictionaries, screen design facilities, report generators and project management tools, among others, are commonly used (27). Perhaps due to the disparity of the many different tools, research focusing on the adoption of software development tools (other than CASE tools) is generally lacking. In this study, we investigate the use of a custom-built tool to support the software development process within a major organization.

Theoretical Model

The basic TAM (as described earlier) is the theoretical model examined in this study. The model includes one external variable, training, as an exogenous variable expected to influence usage through perceived ease of use and perceived usefulness (Figure 1), as discussed in the following sections.

Perceived Ease of Use. Ease of use is defined as the "degree to which the prospective user expects the target system to be free of effort" (11, p. 985). EOU is very similar to the concept of complexity from Rogers' (34) DOI theory and is a well-defined construct in the literature. Generally, EOU is related to usefulness and acceptance (intention or use), with the relationship to acceptance decreasing over time (i.e., as the innovation is used, EOU becomes less important in explaining usage) (11).

Perceived Usefulness. Usefulness is "the prospective user's subjective probability that using a specific application system will increase his or her job performance (11, p. 985). In most studies, usefulness has proven to be the major determinant of acceptance. Over time, the relationship between usefulness and use gets stronger, compared to the relationship between EOU and use. Usefulness can be measured prior to or after actual use. If measured before, it provides an indication of the anticipated usefulness of the innovation; afterwards, it indicates perceived usefulness of actual use.

Training. Training has proven to be an important determinant in explaining usage for innovations (e.g., 4, 9). The concept of training has also been used as an exogenous variable in the TAM. Chau (7), in a study of the adoption of CASE tools by systems developers, found training (called "transitional support" in the study) influenced ease of use. Igbaria, et al. (20) further segmented training into external and internal training and found significant relationships to ease of use and usefulness, respectively. In this study, as shown in Figure 1, training is treated as an exogenous variable and is expected to influence both ease of use and usefulness.

RESEARCH METHODS

Instrument Development

From the theoretical model of tool use illustrated in Figure 1, an instrument was developed to examine determinants of use. A seven-point Likert scale was used for each of the questions with the possible responses ranging from 1=strongly disagree to 7=strongly agree. Questions for ease of use and usefulness were adapted from prior studies (10, 20, 23, 36). Questions for training were borrowed from Chau (7) and Igbaria, et al. (20). Use is measured by a single item (4-point scale) indicating depth of use (2, 13). Constructs and their respective items are shown in Appendix A.

Sample

A good example for this type of study involves adopters who have knowledge about the innovation; have the opportunity to use it, but are not mandated to do so; have only recently begun using it; and are still in the process of forming opinions about it (2). This type of sample would be difficult, or impossible, to obtain using a cross-sectional survey. Therefore, the information systems department of a single organization fitting the above criteria was used to fulfill the data requirements for this study.

The survey instrument was administered to a group of software developers at the selected organization (a multi-billion dollar, publicly held organization.). At the time of data collection, the company employed over 200 IT people, of which 138 were application developers. The company had recently (within the past three months) introduced the new software development tool. The tool was created in-house and consisted of a set of templates implemented in Lotus Notes. Each template contained instructions on use and most contained a sample. Training was provided in-house on how to use the Lotus notes interface and associated templates. Use of the tool was not mandatory.

The survey instrument was sent to each of the 138 application developers. Eighty-five developers participated in the study for a response rate of 62%. Of the developers participating in the study, 54 were male, 22 were female, and 9 did not report their gender. The average age of the respondents was 33 years with a reported average of 9.3 years of development experience. The average number of years the respondents had been with the company was 3.6.

Of the 85 developers responding to the survey, 72 were aware of the tool; 60 of them were aware and used the tool. Thus, the data analysis is based on the 60 developers who actually used the tool.

RESULTS

The data were analyzed using the SAS System's (version 8) CALIS procedure; the models tested were covariance structure models. A two-step procedure based partially on an approach recommended by Anderson and Gerbing (5) was performed. The first step included a confirmatory factor analysis to develop a measurement model that demonstrated an acceptable fit to the data. In the second step, the measurement model was modified to represent the theoretical model of interest.

Measurement Model

The measurement model was estimated using the maximum likelihood method. The chi-square value for the model was statistically significant ($\chi^2(132, N=60) = 230.75$; $p<.001$). Technically, when the proper assumptions have been met, this statistic may be used to test the null hypothesis that the model fits the data. However, in practice, this statistic is sensitive to the sample size and to departures from multivariate normality, and may often result in the rejection of a model that has a good fit. Therefore, it has been recommended that this statistic be used as a goodness of fit index with smaller chi-square values relative to the degrees of freedom indicating a better model fit (22). This being the case, the chi-square/df ratio is 1.748. Carmines and McIver (6) recommend that any value under 2.0 is reasonable as a beginning for analysis. However, caution is suggested in using this heuristic; therefore, other indicators are also considered.

The goodness of fit indices for the measurement model (M_m) are presented in Table 1. The measurement model demonstrates acceptable, although not excellent fit, according to the goodness of fit indicators (specifically, CFI, NNFI, and NFI are not greater than .9). Based on the theoretical foundation of the model from previous research, the measurement model M_m was tentatively accepted as the "final" measurement model and the reliability and validity of the model were tested.

TABLE 1
Goodness of Fit Indices

Model	Chi-Square	Df	Indices NFI	NNFI	CFI
Recommended values	--	--	.90	.90	.90
Measurement Model M_m)	230.75	132	.795	.883	.899
Theoretical Model (m_t)	258.91	148	.779	.872	.889

Note: n=60
NFI=normed-fit index
NNFI=nn=normed-fit index
CFI=comparative fit index

The standardized factor loadings for the indicator variables are shown in Appendix A. The t-scores obtained for the coefficients in Appendix A range from 3.393 to 9.948 showing all of the factor loadings are significant (p .001). These findings support the convergent validity of the items (5). Appendix A also shows the composite reliability, a measure comparable to coefficient alpha (15), for each of the constructs. All three of the scales possess acceptable levels of reliability with coefficients greater than .70. the last column in Appendix A gives the variance extracted estimate, which is a measure of the variance captured by the construct relative to the variance coming from random measurement error. Fornell and Larcker (15) recommend that the variance-extracted estimate be greater than .50, which is the case for all three constructs. Overall, these analyses indicate support for the validity and reliability of the indicators and constructs of the measurement model.

Structural Model

Table 1 gives the goodness of fit indices for the theoretical model (M_t). The Normed Fit Index (NFI) was .779, the Non-Normed Fit Index (NNFI) was .872, and the Comparative Fit Index (CFI) was .889. Even though these indices could be better, they do indicate that the model was an adequate fit. Analysis of the model's residuals revealed that several of the normalized residuals were relatively large (greater than 3.0). Table 2 shows the standardized path coefficients. Only three of the five paths were significant, the path from training to ease of use, the path from ease of use to usefulness, and the path from ease of use to usage. In order to test the nomological validity of the theoretical model, a chi-square difference test was conducted to compare the theoretical model to the measurement model. The resulting chi-square difference value of 28.16 with 16 degrees of freedom was not significant compared to the critical chi-square value of 39.252. Since a finding of no significant difference indicates that the theoretical model is significant in accounting for the relationships between the latent constructs, the initial theoretical model is deemed acceptable. The model, with standardized path coefficients appearing on the causal paths is shown in Figure 2. The R^2 values for usage, usefulness, and ease of use are .27, .56, and .22, respectively.

TABLE 2
Standardized Path Coefficients

Dependent Variable/ Independent Variable	Theoretical Model
Usage	
Usefulness	.0494
Ease of Use	.4784*
Usefulness	
Ease of Use	.7885**
Training	-.0852
Ease of Use	
Training	.4704**

*p<.05, ** p<.001

DISCUSSION

Interpretation of Results

Although most of the application developers in this study were aware of the tool, only 60 of the 85 respondents used it (70%). Furthermore, on average, the tool was used on *some* of the projects (usage: rarely, some, most, all projects; see Appendix A). Thus, use is, at this point, not widespread. Ease of use indicators hovered around the mid-point (i.e., $4 \pm .5$), usefulness indicators were slightly higher than the mid-point, and training tended to be viewed slightly negatively.

As expected, the following significant relationships were found: (1) between training and ease of use; (2) between ease of use and usefulness; and (3) between ease of use and usage. Unexpectedly, significant relationships were not detected between training and usefulness or between usefulness and usage.

Training, as indicated earlier, focused on using the Lotus Notes interface and the templates that comprise the tool. Based upon information provided by the participating organization, potential benefits of the tool, such as higher quality and productivity, were not espoused during the training. Thus, it is not surprising that training is significantly related to ease of use, and not significantly related to usefulness. In this particular case, developers felt training was lacking which led to lower perceptions of ease of use. Igbaria, et al. (20) and Chau (7) also found significant relationships between training and ease of use.

The relationship between EOU and usefulness is consistent with most other TAM studies (e.g., 10, 23). According to Davis (10, p. 335), "...all else being equal, the easier a system is to interact with, the less effort needed to operate it, and the most effort one can allocate to other activities contributing to overall job performance." Although the relationship between these two constructs is almost always found, the explanation for the exact relationship is still unclear. Davis (10) suggests usefulness mediates the relationship between EOU and usage. Others indicate that the relationship is much more complex and may be influenced by such things as time frame, the innovation, and the person, among others (1, 23). In this study, usefulness does not appear to mediate the relationship between EOU and usage; the explanation is perhaps embedded in the remaining relationships of EOU → usage and usefulness → usage.

Why is the relationship between EOU and usage significant? Why is the relationship between usefulness and usage not significant? There are several possible explanations. First, as prior studies have found, the EOU → usage relationship is important early, but diminishes over time (11). The developers in this study had only been using the tool a few months. Second, EOU is an important determinant of use for a complex tool (2), such as the SDT in this study; conversely, it is not as important for relatively easy tasks (which explains the lack of findings in some studies). Third, the true benefits of a tool may not be realized until developers have had a chance to use it on multiple phases of a project or until several months have elapsed depending on the nature of the projects (i.e., longer projects will take longer to realize benefits). Thus, developers may not have had time to evaluate true usefulness. Fourth, all development tools are meant to support the development effort (i.e., to be useful). How each tool does this varies greatly; thus, the differentiator among tools may be ease of use (1). Fifth, curiosity may have driven the use of the tool; they may have simply wanted to use it without demonstrated benefits (2). If so, ease of use is a stronger determinant of use than usefulness.

Although unusual, the EOU → usage and the lacking usefulness → usage relationships are not unheard of. Adams, et al. (1) found EOU related to usage but usefulness not related to usage in a study of WordPerfect and Harvard Graphics use. Chau (7) also found similar results in a study of CASE acceptance by systems developers.

Implications and Future Research

Overall, this study demonstrates properties consistent with other innovations as modeled by the TAM. Training was the only exogenous variable investigated and it proved to be important. Initial training focused on how to use the tool, but avoided the issue of benefits. Also, use was relatively low in this study, with EOU its main determinant. Future training for this organization should address both "how-to use the tool" and "why one should use the tool." It is probably the case that EOU is enough to get developers to begin using the tool, but not enough to warrant continued use. EOU, as shown many times before, will diminish over time (10).

The relatively low R^2 for usage (.27) indicates that much is left to be explained. Other variables that should be considered in future studies include the broader set of innovation characteristics (34), organizational structure (40), management support (7, 20), organizational goals (19), subjective norm (3), image (38), job relevance (38), and voluntariness (26), among others. Also, because current use is not a predictor of future use, effectiveness should also be considered (2).

To truly understand the innovation process, a longitudinal study is needed. Ideally, intention to use and corresponding determinants would be studied, followed by actual use and determinants, followed later by continued use. Obviously, this type of study is difficult because it requires the proper circumstances and the willingness of an organization (or organizations) to be followed through the innovation process. After studying the innovation process from one or more organizations, it is hoped that an instrument can be developed to be used cross-sectionally by any organization.

CONCLUSION

In this study, TAM was applied and proven useful for explaining the use of a software development tool. Results of one company's use of a tool revealed (1) training affected ease of use, (2) ease of use was related to usefulness, and (3) ease of use was the major determinant of usage. Because the company has only been using the tool a short time and the training focused on how to use the tool, the findings are consistent with expectations. However, the model leaves room for explanation. Future studies will need to include a set of relevant external variables related to software development innovations, in general, and software development tools, in particular.

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FIGURE 1
Modified Technology Acceptance Model (adapted from Davis, et al. 1989)

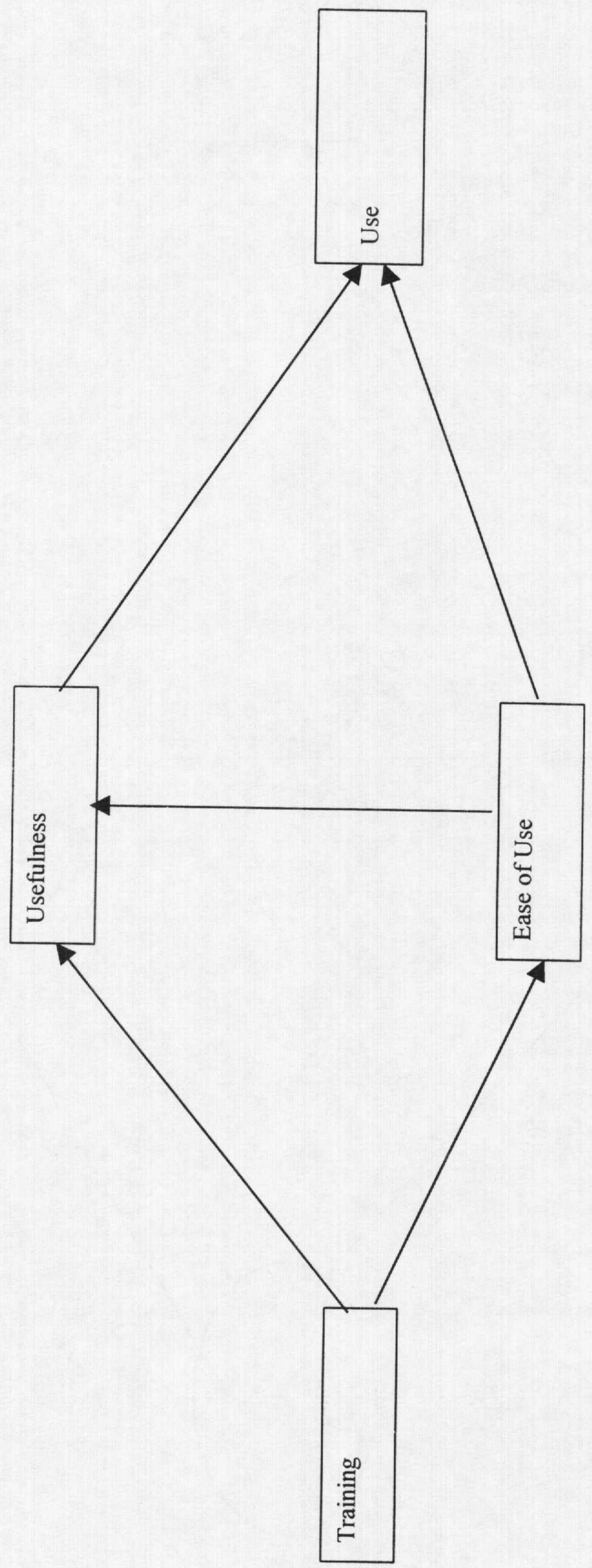
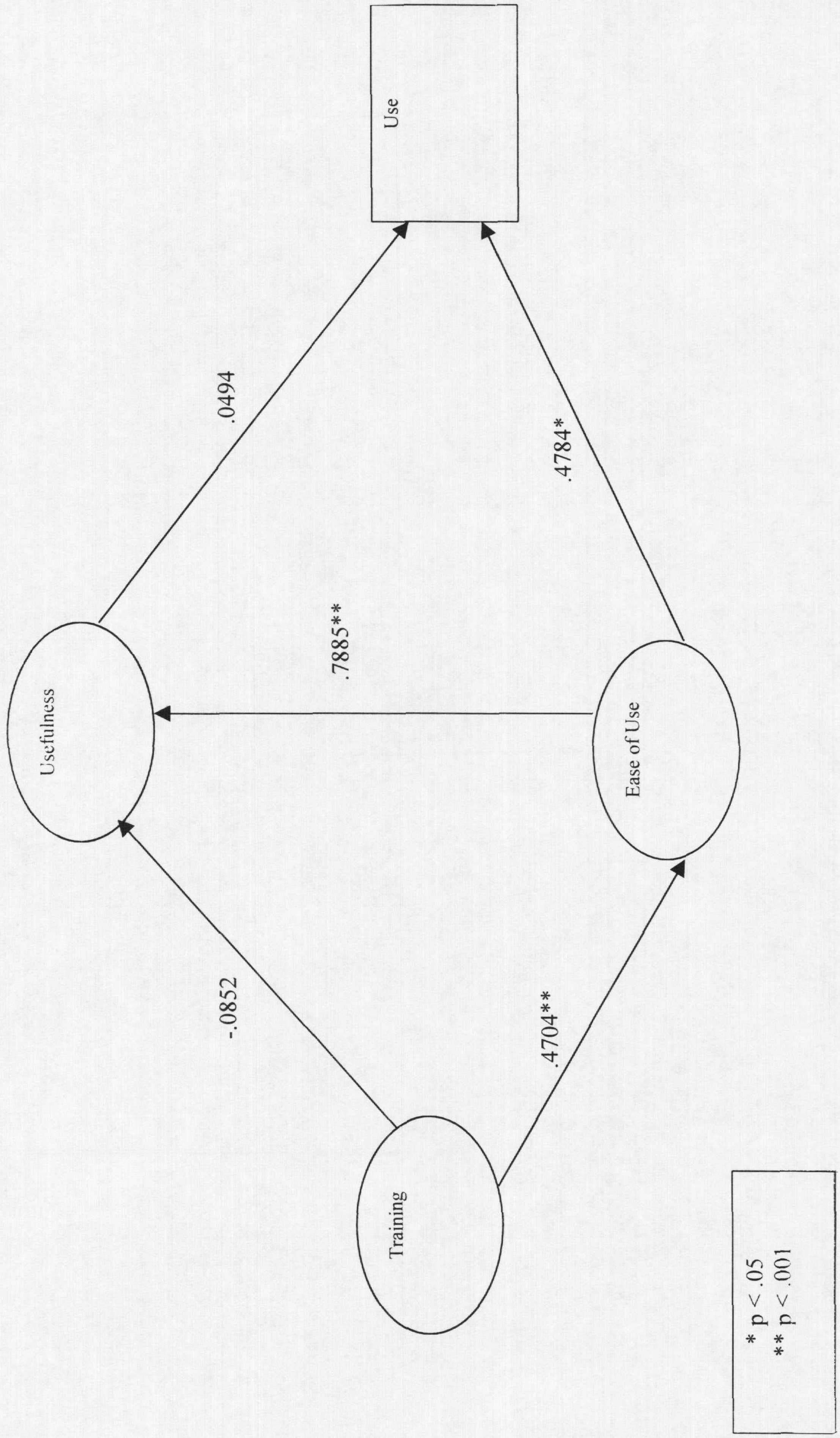


FIGURE 2
Final Model



APPENDIX A
Instrument Statistics

Item	Mean	Standard Deviation	Standardized Loading	T	Reliability	Variance Extracted Estimate
Variable: USE						
Level of use of the tool (1=all; 2=most; 3=some; 4=rarely)	3.252	1.051				
Construct: USEFULNESS (scale: 1=strongly disagree; 7=strongly agree)					**.957**	**.765**
Using the SDT enables me to accomplish tasks more quickly	4.000	1.766	.769	6.976	.591	
Using the SDT improves my job performance	4.745	1.622	.957	9.948	.916	
Using the SDT increases my productivity	4.321	1.731	.898	8.880	.806	
Using the SDT enhances the quality of my work	5.000	1.667	.911	9.107	.830	
Using the SDT makes it easier to do my job	4.397	1.677	.895	8.835	.801	
The SDT is useful in my job	5.067	1.686	.929	9.422	.863	
The SDT is of benefit to me	5.475	1.625	.676	5.851	.457	
The advantages of using the SDT outweigh the disadvantages	5.203	1.655	.797	7.353	.635	
Construct: EASE OF USE (scale: 1=strongly disagree; 7=strongly agree)					**.910**	**.655**
Learning the SDT was easy for me	4.560	1.729	.871	8.358	.759	
I think the SDT is clear and understandable	3.863	1.721	.851	8.056	.724	
I find the SDT flexible to work with	4.203	1.624	.803	7.356	.645	
It was easy for me to become skillful at using the SDT	4.260	1.513	.878	8.482	.771	
I find the SDT easy to use	4.203	1.581	.904	8.904	.817	
The SDT is not frustrating to use	4.098	1.705	.557	4.549	.310	
Using the SDT does not require a lot of mental effort	3.722	1.575	.431	3.393	.186	
Construct: TRAINING (scale: 1=strongly disagree; 7=strongly agree)					**.836**	**.682**
Specialized instruction and education concerning the SDT is available to me	3.118	1.585	.870	7.547	.757	
Formal guidance is available to me in using the SDT	3.260	1.558	.740	6.149	.548	
I have received adequate training in the use of the SDT	3.488	1.779	.767	6.428	.588	

Note:
- Reliability denotes composite reliability
- All t-tests were significant at $p < .001$