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A Scheme of Technology Acceptance for Mobile Computing

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ABSTRACT

Technology acceptance models have been an important area of research in the Information Systems arena, especially in the last 20 years. This study integrates factors from four models related to the acceptance of mobile computing into a new model termed the Integrated Technology Acceptance Model for Mobile computing (ITAMM). Most technology acceptance studies use factors from Davis's Technology Acceptance Model (TAM), Davis and Venkatesh's Extended Technology Acceptance Model (TAM2), Ajzen's Theory of Planned Behavior (TPB), and/or Goodhue's Task-Technology Fit (TTF) work. Using the definitions of each component in these models, the research assesses which factors should be extracted into an integrated technology acceptance model for mobile computing devices. Subsequent interviews of PDA users resulted in the identification of three additional factors for the integrated model. The factors are adaptability, mobility, and security. This paper presents the ITAMM and the results of multiple regressions analyses for the new model

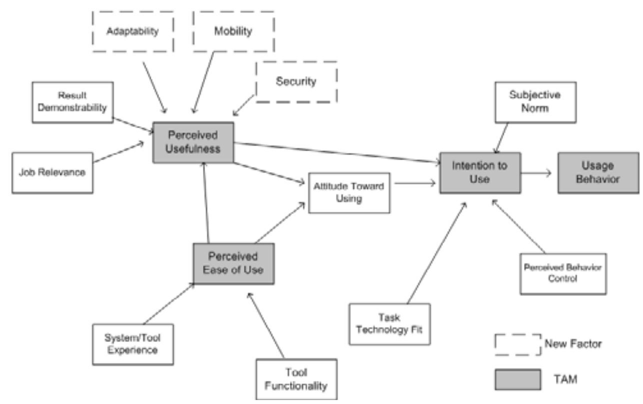
1. INTRODUCTION

Research investigating information technology acceptance based on modeling and measuring individual motivational characteristics has been of critical importance in the past twenty years. Insight into technology acceptance models for small mobile computing devices is especially needed today because the use of mobile computing devices by a variety of industries is expanding significantly. Uses include interactions with the whole continuum of healthcare services, for example. Examples of mobile computing include laptop computers, handheld devices, and smart phones. No technology acceptance research has looked specifically at mobile computing devices although more and more information is available outside the work environment, and more work is done in a location independent environment.

2. PURPOSE OF THIS RESEARCH

This study addresses this critical need for research into technology acceptance criteria for mobile devices. The purpose of this paper is threefold. First, the study improves the understanding of technology acceptance for mobile computing devices. It does this by examining the components of four well known technology acceptance models: Davis's Technology Acceptance Model (TAM), Davis and Venkatesh's Extended Technology Acceptance Model (TAM2), Ajzen's Theory of Planned Behavior (TPB), and Goodhue's Task-Technology Fit (TTF) work. Using the definitions of each component the research assesses which factors from these models to extract into an integrated technology acceptance model for mobile computing devices. This technology acceptance model is named ITAMM standing for Integrated Technology Acceptance Model for Mobile Computing and can be seen in Figure 1. This derived model is useful for studying technology acceptance not only for mobile computing but also for location dependent domains, since the factors are derived from general-purpose technology acceptance models.

Figure 1. Integrated Technology Acceptance Model for Mobile computing (ITAMM)



Second, the research assesses this integrated model by creating a questionnaire based on existing research augmented by interviews with beginning nursing students and existing PDA users. The instrument was used to survey 134 PDA users including nursing students with experience using the PDAs, chief information officers, college employees and graduate students. Analyses of the questionnaires include multiple regression, correlation statistics, and data mining techniques. The research uses a set of new analysis techniques, namely data mining, which shows the integrated model is the one of the best predictors of the measurement of usage behavior. Furthermore the data mining information gain analysis find mobility to be the second largest predictor variable for intention to use indicating that in the minds of these users mobility is significantly important in accepting the technology. The results of data mining methods and the relationships with correlation and regression statistical methods are reported in [14]. Several research articles used the PDA as an example of a mobile computing device. For example, Waycott and Hulme [22] studied whether or not PDAs were useful tools for reading and learning materials. One finding of their research was that students welcomed the portability of the device. An August 2003 Gartner Report by Troni and Cozza [20] concludes that PDAs are data-centric mobile devices, and hence one of their benefits is the increased productivity of users who are on the road or working at remote off-site locations

Third, the research studies the relationships among the technology acceptance model's 15 factors.

3. THE INTEGRATED MODEL OF TECHNOLOGY ACCEPTANCE FOR MOBILE COMPUTING (ITAMM)

The Integrated Technology Acceptance Model for Mobile Computing Devices (ITAMM) draws upon the knowledge of four popular technology acceptance models. As noted earlier these models are Davis's Technology Acceptance Model (TAM), Davis and Venkatesh's Extended Technology Acceptance Model (TAM2), Ajzen's Theory of Planned Behavior (TPB), and Goodhue's Task-Technology Fit (TTF).

Davis' original Technology Acceptance Model developed in 1989 has four factors perceived ease of use, perceived usefulness, intention to use and usage behavior. These four factors are seen in most technology acceptance models [2, 6, 15-17, 21].

Three of the factors from the Theory of Planned Behavior model that are also part of TAM are added to the ITAMM model. These are attitude, subjective norm, and perceived behavior control. The three types of belief (behavioral, normative, and control) are not included in the ITAMM model (see figure 1). The rational for the exclusion of the "belief" items in ITAMM is that their concepts are collapsed into their respective boxes. Behavioral beliefs and evaluations are folded into attitude. Normative beliefs and motivations are folded into subjective norm. Control beliefs and facilitations are folded into perceived behavior control. Fishbein and Ajzen [8] used subjective norm and attitude in their model.

The third technology acceptance model in chronological order is Venkatesh and Davis's Extended Technology Acceptance Model (TAM2), which was developed in 2000. Their factor "voluntariness" was not included in the ITAMM model because its use has been seen as a moderating factor in previous research. As this is not the type of study that specifically tracks mandatory and non-mandatory usage of the mobile computing device, this research folds voluntariness into subjective norm. That leaves only the factors job relevance, result demonstrability, and experience left from the Extended technology Acceptance Model, to be included in the ITAMM model.

Goodhue[12] describes task-technology fit as the ability of information technology to support a task. This implies matching the capabilities of the technology to the demands of the task [12]. Dishaw and Strong [6] add that information technology will be used if and only if the functions available to the user support the task(i.e. fit). Dishaw and Strong make a case that tool experience can be a factor that influences perceived ease of use. The ITAMM keeps tool functionality because it is seen as an antecedent of perceived ease of use.

Therefore the definitions of the 15 factors in the ITAMM model are as follows:

- *Adaptability* is the degree to which individuals believe it is important that they can add hardware and/or software to their device.[14]
- *Attitude Toward Using* is the strength of the users feeling of favorableness or unfavorableness toward using a mobile computing device [8].
- *Intention To Use* is defined as the user's intention to use a mobile computing device [4].
- *Job Relevance* is the user's perception that using a mobile computing device is linked to the user's job [8].
- *Mobility* is defined as the degree to which an individual believes that it is important that their device can be used in different geographic environments. [14]
- *Perceived behavior control* is defined as the user's perception of the presence or absence of requisite resources, opportunities and facilitating condition necessary for using a mobile computing device[1].
- *Perceived Ease Of Use* is the degree to which a person believes that using a mobile computing device would be free of effort [4].
- *Perceived Usefulness* is the degree to which the user believes that using a mobile computing device would enhance his or her job performance [4].
- *Result demonstrability* is the tangibility of the results of using a mobile computing device [18].
- *Security* is defined as the degree to which a person feels that security is important to them. [14]
- *Subjective norm* is defined as the perception that most people who are important to him/her think that he/she should or should not use a mobile computing device [8] .
- *System Or Tool Experience* is the length of elapsed time since the user first used a mobile computing device [13].
- *Task-Technology Fit* is the user's perception of the ability of a mobile computing device to support a task [12].
- *Tool Functionality* is defined as the perception that a mobile computing device performed specific functions [6].
- *Usage Amount* is the degree of current usage of the mobile computing device [4].

4. BACKGROUND OF THE QUESTIONNAIRE

Most of the items for this questionnaire were adapted from previous published research investigating technology acceptance models for IT systems and devices. Therefore, these questions have some historical validity.

The statements for *adaptability* are the same as the definition of adaptability[14] and relate to the degree to which an individual believes that it is important that they can add hardware and/or software to their device.

Attitude toward using is an item in the study by Moon and Kim [17] The resulting questions come from this research.

In TAM2 *intention to use* measured the participant's intention to use a particular system. Thus participants were asked what they would do if their device broke. That is, if for some reason their PDA broke, (assuming they had the money) would they purchase a new PDA

Job relevance questions came from Venkatesh and Davis's [21]. The statements for *mobility* are the same as the definition of mobility[14] which is the degree to which individual's believe that it is important that their device can be used in different geographic environments.

Perceived behavior control questions come from Taylor and Todd's [19]. *Perceived ease of use*, *perceived usefulness*, and *result demonstrability* are the same questions from TAM2 [21].

Subjective norm uses the questions used in TAM2 [21]. Similar questions are seen in the research of Taylor and Todd [19]

The statements for *security* are the same as the definition of security[14], which is the degree to which a person feels that security is important to them. Security is an important issue when a person is storing information that should remain private or when they are uploading information to a storage medium.

System or tool experience builds upon an idea proposed in Hubona[13], that computer experience is the years of experience using a computer for any purpose. The *task-technology fit* question fits the definition used in this research, which is the user's perception of the ability of a small mobile computing device to support a task. The *tool functionality* question is a result of the definition of tool functionality defined as the perception that a small mobile computing device performed specific functions[6]. *Usage* asks the respondent to rate their current usage of the PDA for a week.

5 RELIABILITY OF THE SURVEY INSTRUMENT

Cronbach's Alpha tests the internal consistency of the test items. The measurement can be determined from a single administration of a single form of the test. A typical example of using Cronbach's Alpha is estimating the internal-consistency and reliability of an attitude scale, where the statements being measured would use a Likert-Scale. Such is the case with this research. The number for an acceptable Cronbach's Alpha is at least 0.70 by some social science researchers; others use 0.75 or 0.80 [9]. Eleven of the factors use multiple questions as their basis. The other four factors (Intention to Use, System or Tool Experience, Task-Technology Fit, and Usage Behavior) are all based on single questions; thus, the reliability test is not done on these four factors. The following **Table 1** presents the reliability measure for the 11 factors.

Table 1. Cronbach's Alpha (indicates a factor added to the integrated model)*

Factor	Cronbach's Alpha
Adaptability *	.7584
Attitude toward using	.7002
Job relevance	.7609
Mobility *	.4633
Perceived behavior control	.6331
Perceived ease of use	.6863
Perceived usefulness	.7229
Result demonstrability	.7404
Tool functionality	.6844
Security *	.8804
Subjective Norm	.6242

It should be noted that except for mobility all of the other factors with a value less than 0.70 are constructed from questions that have been validated by other technology acceptance model researchers. The low score for the factor mobility shows that the construct mobility lacks internal consistency resulting in a low Cronbach's Alpha. The two other new factors (security and adaptability) both meet the 0.70 threshold.

6. REGRESSION ANALYSIS

Figure 2 gives a snapshot view of the regression results. It details the sign (positive or negative) of the standardized coefficient. For example, when perceived usefulness is the dependent variable, one can see that the sign of the factor job relevance is positive and significant. Therefore, a one-unit change to job relevance results in a positive increase to perceived usefulness. The asterisks indicate relationship is significant; that one cannot claim that the relationship was accidental. Figure 2 summarizes the relationships between the factors (+ = positive relationship, - = negative relationship, ** = significant at the .01 level. Table 2 details the standardized coefficients and their associated t-value.

6.1 Perceived Usefulness

Result demonstrability, job relevance and perceived ease of use all positively influence perceived usefulness. The coefficients give limited information, but most of the signs of the coefficients agree with the literature. Venkatesh and Davis [21] and Chismar and Patton [2] showed in their research that job relevance had a positive effect on perceived usefulness Venkatesh and Davis [21] showed in their research that result demonstrability had a positive effect on perceived usefulness. In Venkatesh and Davis's study, result demonstrability was not statistically significant at the 0.05 level. Venkatesh and Davis [21], Mathieson and Chin [16], Dishaw and Strong [6], Moon and Kim [17], Hubona and Geitz [13], and Taylor and Todd [19] showed in their research that perceived ease of use had a positive effect on perceived usefulness In Venkatesh and Davis's study, perceived ease of use was not statistically significant at the 0.05 level.

Figure 2. Snapshot view of the regression results

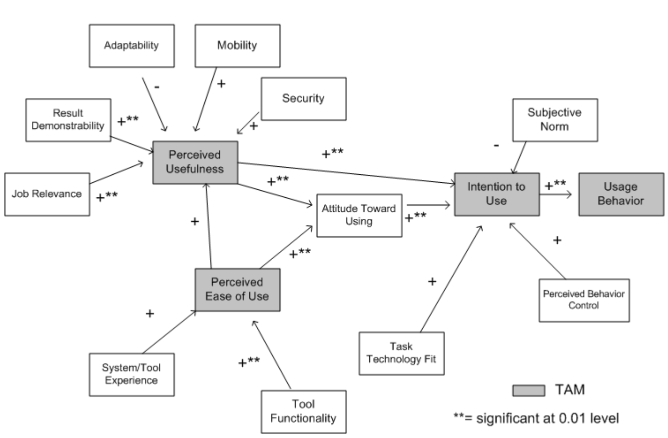


*Table 2. Regression results (** significant at 0.01 level, *=significant at 0.05 level)*

	Standardized Coefficients	t	Sig.
	Beta		
Adaptability	-0.0809	-0.9648	0.3366
Job Relevance	0.4528	4.8870	0.0000**
Mobility	0.0650	0.6572	0.5123
Perceived Ease of Use	0.0515	0.6324	0.5283
Result Demonstrability	0.3201	4.0693	0.0001**
Security	0.0740	1.0131	0.3131
Dependent Variable: Perceived Usefulness			
	Standardized Coefficients	t	Sig.
	Beta		
System or Tool Experience	0.0819	1.2718	0.2057
Tool Functionality	0.6674	10.3603	0.0000**
Dependent Variable: Perceived Ease of Use			
	Standardized Coefficients	t	Sig.
	Beta		
Perceived Ease of Use	0.2410	3.1344	0.0021**
Perceived Usefulness	0.4699	6.1107	0.0000**
Dependent Variable: Attitude Toward Using			
	Standardized Coefficients	t	Sig.
	Beta		
Attitude Toward Using	0.2492	2.7476	0.0069**
Perceived Behavior Control	0.0429	0.4940	0.6222
Perceived Usefulness	0.3529	3.8700	0.0002**
Subjective Norm	-0.0778	-0.9398	0.3492
Task Technology Fit	0.1466	1.8261	0.0702
Dependent Variable: Intention to Use			
	Standardized Coefficients	t	Sig.
	Beta		
Intention to Use	0.6869	10.6934	0.0000**
Dependent Variable: Usage Behavior			

The three new factors that are introduced in this research produced mixed results. Security and mobility both positively influence perceived usefulness, but adaptability did not. Adaptability is inconsistent with the results of the questionnaire which said that over seventy percent of the respondents thought that adding software and hardware was important. This might seem to indicate that the addition of extra accessories resulted in the PDA device being harder to use.

6.2 Perceived Ease of Use

Both system or tool experience and tool functionality positively influence perceived ease of use. These results are consistent with the literature. Dishaw and Strong's [6] research showed that tool experience had a positive effect on perceived ease of use. Dishaw and Strong's [6] research also said that tool functionality had a positive effect on perceived ease of use. Hubona and Geitz [13] also found system experience had a positive effect on perceived ease of use.

6.3 Attitude

Perceived ease of use and perceived usefulness both positively influence attitude. These results are consistent with the literature. Mathieson and Chin's [16], Moon and Kim's [17], Hubona and Geitz's [13], and Taylor and Todd's [19] research said that perceived ease of use had a positive effect on attitude towards using. Mathieson and Chin's [16], Hubona and Geitz's [13], and Taylor and Todd's [19] research shows that perceived usefulness had a positive effect on attitude towards using

6.4 Intention to Use

Attitude toward using positively relates to intention to use. This is consistent with the literature. Moon and Kim's [17] and Dishaw and

Strong's [6] research said that attitude towards using had a positive effect on intention to use. Task-technology fit is positively related to intention to use. Finally, perceived behavior control is positively related to intention to use.

6.5 Usage Behavior

Intention to use is positively related to usage behavior. This result is consistent with the literature. Mathieson and Chin's [16], Taylor and Todd [19], and Venkatesh and Davis [21], research showed that intention to use had a positive effect on usage.

7. CONCLUSION

The ITAMM model integrates four well-known technology acceptance models and creates a robust model for mobile computing devices. It has added three new factors (adaptability, mobility, and security) that act as antecedents of perceived usefulness, which is one of two foundational belief constructs in technology acceptance model theory.

Using regression analysis, this research has shown how the factors in the ITAMM model influence one another. Historically researchers have explored technology acceptance models that looked at World Wide Web [17], telemedicine [3], healthcare computer systems [5], family physicians [7], e-mail [10], and e-commerce[11] just to name a few. The ITAMM should be equally effective in these and other research domains whether mobile or location dependent, since the model integrates standard models and is one of the best predictors of the measurement of usage behavior. In some cases the prediction is several percentage points higher for each of the four contributing models[14].

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