Evaluating the Development Factors for Information Systems for Mobile Devices

Juan Reynoso[1], Wichian Chutimaskul[2], Lorne Oflman[3], Marcelo Ramos[1], Peter Ractham[4]
Universidad Politicnica de Aguascalientes, Mexico[1]
King Mongkut's University of Technology Thonburi, Thailand[2]
Claremont Graduate University, USA[3]
Thammasat University, Thailand[4]
{jmgr, jperez}@correo.uaa.mx[1], wichian@sit.kmutt.ac.th[2], lorne.olfman@cgu.edu[3], Peter@tbs.tu.ac.th[4]

***Abstract*—The use of mobile devices (MD) presents a very important opportunity for end users. By using these devices, they can perform tasks on-the-move as well as keep in contact with organizations, customers, and clients. Consequently, developers of information systems (IS) for such devices should pay special attention into overcoming any potential negative impacts in the user's perception. Around the world, MDs are becoming one of the most important technologies used by organizations and individuals. We believe that the developers for this type of device must be aware of the critical factors in the design that could affect the adoption of this technology. We conducted a study in a financial institution that has a presence in all of the Mexican territory using an exploratory factorial analysis and a reliability analysis. Nine factors were identified. In addition, using such factors we instantiated an ISMD that was tested in order to understand whether understanding and using such factors would deliver better acceptance compared to the traditional approach. This was conducted using a quasi-experimental design. Results show that in 33 out of 35 aspects it is better for developers to take into account such factors.**

Keywords— End-users behaviour, mobile devices, end-user interface, critical development factors, cognitive absorption.

I. INTRODUCTION

The use of mobile computers has allowed advancements in many aspects of every-day life beyond just the writing-desk [6]. 2011). In addition, mobile computing such as personal digital assistants (PDA), tablets, and smart phones have replaced and/or complemented traditional computers in many aspects of people's lives. Globally, the use of Mobile Devices (MD) has increased at a very rapid pace [44] especially in the last decade pace [41].This enables opportunities for MD users to interact anywhere at any time with organizations, customers, and clients. The use of MDs provides opportunities for its users to be ubiquitously connected with their networks [16]. For instance, the arrival of the mobile Internet offers a significant opportunity for consumers and organizations to offer services and innovative applications pace [44] as well as to create new markets, create new ways of doing business and change industrial structures in existing markets [41].

Devices and systems based on mobile technology have become very common in our society [5]. Technologies based on mobility that were designed for individuals were developed bearing in mind users' differing requirements and needs [24]. Likewise the development of information systems for mobile devices (ISMD) has been increasing steadily in number as well as in variety. In addition, the emerging trend in ISMD development is gearing toward organizational requirements, including some of their business processes to complement and the serve the mobile workforce. However, there are high levels of concerns among the ISMD users. [46] argues that not all employees may have secure access to the mobile technology, people could feel threatened by using it because these mobile devices are frequently lost, stolen or damaged. Thus, it is important that ISMD developers take into account a set of very important users concern aspects to minimize the risks to the users as much as possible. Especially, in cases where those users have already spent some time familiarizing themselves with such technology.

The present study is an update of a study performed two years ago in a Mexican financial organization. The organization's main business is processing car loans for any client who wants to buy a new car. The adopted ISMD specially developed for this purpose, uses an application in car dealerships and sends the information wirelessly to the central office. Before using this application, the complete process required about 3 days; by using the system, the time was reduced to 6 hours. Therefore, it can be deduced that the application saves time and money for the financial organization. The main goal of this research was to find out whether the initial perception of the user has been affected by the continuous use of such technology. The evidence found suggests that there are significant changes in a user's perception as they become more familiar with the new way of performing related tasks.

II. LITERATURE REVIEW

MDs usage is having very important/significant growth around the world. For example, in Mexico the COFETEL (COFETEL 2011) reports that for the 4th quarter of 2011, there were 84.2 cellular phones for each 100 inhabitants with a net growth of 3.9 million subscribers per year. Past literature [1], [2], [3], [12], [20], [26], [38] and [48] tried to identify the critical factors that affect various technology adoptions. These

studies used different models and/or approaches to identify factors for different technologies, but none were specific to ISMD and mobile devices. Based on that, we conducted our study to recognize the most important factors for the development of ISMD in a Mexican setting. We started with a proposed model, which was based on the existing literature (see Figure I). This study attempted to serve as a starting point and help the ISMD developers to identify the main attributes that Mexican mobile users consider as critical. We applied the survey at all the organizational levels identified in previous literature [37] –strategic, administrative, knowledge and operational– of a financial institution. The following sections describe how the model was constructed.

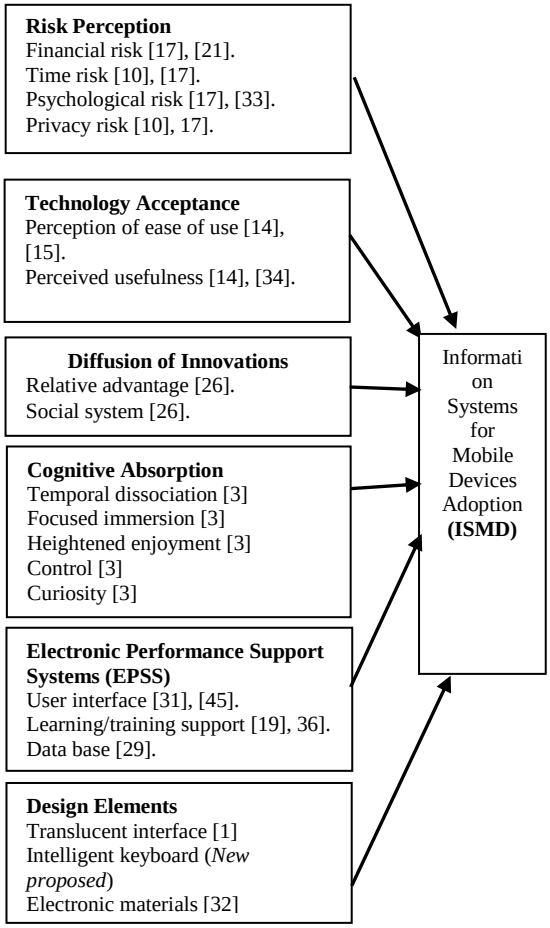

FIGURE 1. MODEL FOR ISMD ADOPTION

A. Risk Perception

Technology is continually updated; therefore, it is important to identify a user's risk perception in relation to the use of new technologies [17].because it is very important to understand the critical elements in order to develop better IS [9]. Existing literature [10], [17], 20], [47] tried to identify the risk perceptions of IT users. For example, financial risk represents the potential risk that involves monetary investment associated with the cost of purchase or development and the subsequent maintenance cost of an information system [17], [21]. This type of risk includes the potential risk of financial loss because of fraud as well as the financial loss if the IS product or service is not up to standard, or if the IS product/service is cheaper from a different provider. The time risk represents the risk involved with a badly timed purchasing decision or time required for learning to use the product/service, as well as the selection of a replacement [10], [17]. IS users are worried about the risks related to the time required to learn how to use the device, and the problems associated with the product itself [17]. Users also take a psychological risk when trying out a product's performance, which can lead to a negative feeling [17],[33] and the potential risk of losing self-esteem because planned goals are not achieved [10] as expected. Privacy risk [10], [10] happens/occurs when users feel the effects of fraudulent transactions no matter how such a transaction was performed. There are privacy risks in the electronic models of: business-to-business, client-to-business and government-to-citizen [25]. Consequently, this could negatively impact on the adoption of ISMD [17].

B. Technology Acceptance

Previous literature has examined the technology acceptance model (TAM) by Davis [15]. The innovation intention of use is predicted through the perception of its associated ease-of-use (Davis 1989). The perception of ease-of-use is increases progressively until it is perceived as a "public service" [14], [15]. The use of a system that allows improved activity generates a perceived usefulness [15], [34]. [34]. Mobile users could adopt the developed ISMD if it is perceived as having a significantly better interaction compared with the traditional process [34].

C. Diffusion of Innovations

There are four main factors that influence the degree of adoption of a particular innovation: the innovation itself, communication channels, adopter's characteristics, and the social system. An innovation is "something" different compared to existing "things" [38]. It can be something as tangible such as a mobile device or intangible like a technique/theory. There is an objective and subjective dimension regarding innovations and several levels of manifestation and diffusion: person, group, organization and society. These dimensions and levels determine the intensity and depth of an innovation, its degree of diffusion in society and the diversity of environments in which it has been deployed. The processes followed in the development, must be known by the organization's members with the purpose of facilitating adoption. It must be demonstrated that the used processes are those that better adapt to user's needs. In addition, the benefits must be highlighted over the communication channels that support the innovation, so that its real value can be clearly perceived. Consequently, the innovation characteristics influence adoption [38]. The relative advantage identifies the compared benefits of the innovation to existing technology [26]. In addition, the social system refers to the organizations' external and internal individuals that influence the acceptance of the innovation. The external

influence is established by opinions of suppliers, consultants, technical documents, and personnel of different organizations [38]. The social system must have a direct and indirect influence on the individual adoption of new ITs [26].

D. Cognitive Absorption

The cognitive absorption (CA) is the state of deep involvement that the user shows by using an IS and represents an intrinsic situational motivator. Users experience a total involvement where other demands of attention are ignored [44]. The CA is composed of five dimensions [3], which are: temporal dissociation, focused immersion, heightened enjoyment, control and curiosity. In addition, they describe/portray that the holistic user's experiences with technology can be an important variable, which explains its associated acceptance; for example, the intrinsic motivation, which is a state of deep involvement. The temporal dissociation is the inability of the user to record the time while interacting with an IS, which shows a perception of easy use [3]. The focused immersion is the experience of complete involvement, where other demands of attention tend to be ignored due to the fact that users focus all their attention on the task, while reducing the mental level of the cognitive work load [3]. The heightened enjoyment represents the pleasant aspects of the interaction with an IS [3]. The end-user perceives a "problem" while interacting with a new IS, which is reduced as the task is executed over and over again. Therefore, it is important that the user has the feeling of having control over the IS. The curiosity represents the fact that the user feels satisfaction when he's manipulating the IS [3]. So that helps to reduce the perception of cognitive load.

E. Electronic Performance Support Systems (EPSS)

An EPSS integrates a series of attributes that provides support for the work, when and where the aid is needed in the most efficient possible form [7], 18], [19], [36], which includes online and offline resources (Kim 2011). This technology is an integration of artificial intelligence, hypermedia and computer-based training that includes intelligent interfaces, embedded training, an online aid hypertext system and an online intelligent advisory system [31]. In addition, EPSS can be used as an alternative for learning supplementing traditional classroom or training strategies [30]. We believe that it's important for ISMD to include elements of EPSS so that the work environment can be simplified for users. An EPSS guides the users in real time while they are performing the work. These features allow them to navigate between screens and complex fields, reduce training costs as well as the number of errors that must be attended to by the IS department [11]. Through the user interface all IS components are integrated in a single element that enables the users to navigate between the components [31], [45] and to have the following benefits: the ability to execute more tasks, increase user productivity by a 25%, and reduce by 50% the required training time [36]. An IS that includes learning and training support provides simulation, practice, problem solving capabilities, performs analyses and other activities designed to allow users to have experiences or learning abilities/opportunities [36] enhances users to have a self-direction and to experience structured learning [18], [19]. It is important that an ISMD includes support to access, search and retrieve information through the use of a data base because these information resources allow a better organizational information management [29].

F. Elements of Design

The development of ISMD includes design elements specifically created for mobile technology such as translucent interfaces, e-Inputs and intelligent keyboards. A common problem associated with the MD is the limited space to show information and this represents a real challenge in the development of an ISMD [13], [23], [42], and [40]. A translucent interface may help to increase the usability and could be considered as a useful and pleasant addition to enhance acceptance by the users of this technology [1]. The intelligent keyboard emerged from the experience in the development of IS by the development team. The ISMD demands a visibility design completely different to those for IS on normal computers. Three types of keyboards were designed that are controlled by the application itself. When data is being captured in an ISMD, the application will detect the data type intelligently and will display the corresponding keyboard. The goal is to minimize data-entering errors. A web service utilizes a defined interface that can be accessed through the Internet. It is defined by a uniform direction of identification and its associated interface [17]. The web services are very important in models B2C, B2B and in G2C, since they represent forms of providing solutions that strengthen the customer service based on handling the transactions efficiently [39]. Organizations use them to interchange information and to transform the applications into clients that integrate web services coming from different suppliers and further transforming it/them into e-Inputs that configure the operational environment in an MD. (Sorry, I do not understand this sentence – Jan)

III. RESEARCH DEVELOPMENT

A. Survey Creation

The present study identified the aspects considered as important in previous research (as shown in Figure 1). The researchers developed an instrument for the identification of the critical factors in the adoption of the ISMD, which was formed by a total of 75 questions. Each question was measured on a 7 point Likert scale from 1) completely agree to 7) completely disagree. The instrument was tested in a pilot test with 14 people in the first study and proved to be suitable.

B. Data Collection

The sample comprised users of ISMD that worked in one of 48 car dealerships with which a Mexican financial institution has commercial agreements. In the first study, an invitation was sent to all employees of the institution. Participation was possible in one of three forms: through a Web site, by electronic mail and by a paper-based survey. At least two surveys were answered in each car dealership. Table I shows the demographic comparison between both samples.

TABLE I. COMPARISON OF DEMOGRAPHIC DATA

Demographics	Values	Percentage
Gender	Male	64.00%
	Female	36.00%
Grade	High School	11.30%
	College	82.00%
	Graduate level	6.70%
Organizational Level	Tactical	2.00%
	Strategic	16.00%
	Knowledge	18.67%
	Operations	63.33%

C. Factor Analysis and Reliability Measurement

Critical factors for the development of ISMD were identified though an exploratory factor analysis. The measured variables were those shown in Table II. Previous to this analysis, the index of adjustment KMO of the sample was used (.833) and the Bartlett's test of Sphericity ($p < .001$) was calculated. These values show a good sample adjustment and an appropriate correlation between variables, therefore, the data is adequate for the application of the exploratory factor analysis.

The acceptance value for each potential variable was established as .60 as suggested in previous literature [22], [28]. For the study, nine factors were identified that comply with such a requirement.

TABLE II. FACTOR ANALYSIS RESULTS FOR ISMD

Factor	Component	Value
Information Access Support *(α=.882)*	Productive information	.767
	Quality of information	.747
	Training reduction	.667
	Quick access	.657
	Required information	.621
Web Services Implementation *(α=.915)*	eInterface	.812
	eB2B	.773
	eCatalogues	.760
	eValidation	.749
	eB2C	.716
Information Control Loss *(α=.899)*	Fraudulent transactions	.884
	Confidential information	.859
	Client Security Affected	.808
	Privacy	.726
	Incorrect use of information	.706
	Potential fraud	.632
Technology	Technological differentiator	.812
Innovation Benefits *(α=.873)*	Increase in productivity	.692
	Use of resources	.672
	Quality of service	.645
	Self-confidence in technology	.600
Technology ease of use *(α=.884)*	Easy to understand	.871
	Easy to use	.855
	Easy to manage	.799
	Modularity	.625
Cognitive Absorption *(α=.745)*	Smart keyboard	.692
	Sense of curiosity	.690
	Interface design	.635
	Task masterization	.621
Temporary Dissociation *(α=.757)*	Time flies	.803
	Losing time perception	.797
	Longer used time than planned	.683
Psychological Fears *(α=.843)*	Self-esteem lost	.844
	Self-confidence lost	.834
	Psychological confusion	.609
User interface *(α=.834)*	Aesthetics and functionality	.809
	Enhanced visibility	.721
	Increased pleasure	.703

D. Instantiating an ISMD

After identifying the factors we wanted to test the impact of (such factors)/them in a special ISMD. Two developers and three-member teams were formed. (A developer and 3 members made up each of the two teams.) In addition, undergraduate students of a Computer Systems Engineering bachelor degree were invited to join the teams. Invitations were sent to those having the following characteristics: had not failed any previous courses, had at least has a 9.3 grade average (on a scale from 1 to 10) on the four programming courses. The six members were selected randomly and assigned to one of the two teams. These teams were asked to develop a mobile application that was composed of a set of 54 requirements. Each requirement had to be developed as an independent module. The application had to be developed within a six-week time frame using Java as the programming language. In addition, both teams were informed that the activity was a contest between the two in order to prevent communication among teams that could affect the outcomes.

Researchers met independently with each team. Team Without Model (TWM) only received the specification document during the meeting. Team Using Model (TUM) received the specification document and an additional document that included especial indications about the factors found in the previous study. Both teams had a Q&A during the meeting until no more questions were asked.

Both versions were analyzed using a lexical analyzer that calculates Halstead metrics. These metrics were used to test whether they had equivalent quality and removed potential effects that would affect ISMD acceptance by end-users. Data was analyzed using a t-test ($p \leq .05$). Table III shows that there are not significant differences in the 3 Halstead values (N, V, L), therefore, we concluded that both versions were similar.

TABLE III. T-TEST FOR HALSTEAD METRICS

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	N TWM - N TUM	17.02443	103.45643	14.07864	-11.21374	45.26260	1.209	53	***.232***
Pair 2	V TWM - V TUM	58.87756	506.93239	68.98476	-79.48834	197.24347	.853	53	***.397***
Pair 3	L TWM - L TUM	-.00455	.01785	.00243	-.00942	.00033	-1.872	53	***.067***

E. End-User Acceptance Test

For the next step, we conducted a study with a total of 31 participants. They were students from each of the three different groups of the final semester of a Computer Systems Engineering bachelor degree and they were invited in person by the main researcher. 31 accepted the invitation from a total of 73 students.

A questionnaire formed/consisting of 35 questions (one for each variable) was designed and tested with 14 persons in order to identify whether there were errors. No issues were found so the questionnaire was deemed suitable for the study. Each question had to be answered using a 7-point Likert scale from 1) Completely agree to 7) Completely disagree. The higher end-user acceptance value was Completely agree.

The study was conducted simultaneously in a computer laboratory. The order for testing the two versions was assigned randomly, some evaluators first tested the TUM and the TWM after; the others, the other way around.

At the end of each evaluated version, evaluators filled out an online questionnaire.

Once the data was collected, we conducted a Paired Samples t-Test using a significance value of .05. Table 4 shows the results. We can see that only 2 out of the 35 values were not significant: Required Information and eB2B. We believe that these were because both teams presented about the same information to end-users for decision-making purposes and the application did not require a connection to perform Business-to-business transactions. In addition, it is important to add that in all cases the TUM version had a higher mean acceptance value compared to the TWM (see columns 2 and 3). For the next step, we conducted a study with a total of 31 participants. They were students from each of the three different groups of the final semester of a Computer Systems Engineering bachelor degree and they were invited in person by the main researcher. 31 accepted the invitation from a total of 73 students.

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TABLE IV. T-TEST FOR END-USER ACCEPTANCE

	TUM Mean	TWM Mean	Paired Differences					t	df	Sig. (2-tailed)
			Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
						Lower	Upper			
Productive information	1.61	2.19	-.581	.923	.166	-.919	-.242	-3.503	30	.001
Quality of information	1.32	2.00	-.677	.653	.117	-.917	-.438	-5.780	30	.000
Training reduction	1.42	1.94	-.516	.890	.160	-.842	-.190	-3.230	30	.003
Quick access	1.77	2.26	-.484	1.151	.207	-.906	-.062	-2.341	30	.026
Required information	*1.32*	*1.65*	*-.323*	*.979*	*.176*	*-.682*	*.037*	*-1.834*	*30*	*.077*
eInterface	1.39	1.84	-.452	.768	.138	-.733	-.170	-3.276	30	.003
eB2B	*1.42*	*1.74*	*-.323*	*.909*	*.163*	*-.656*	*.011*	*-1.976*	*30*	*.057*
eCatalogues	1.35	1.74	-.387	.667	.120	-.632	-.142	-3.230	30	.003
eValidation	1.45	1.90	-.452	.675	.121	-.699	-.204	-3.724	30	.001
eB2C	1.45	2.06	-.613	.803	.144	-.908	-.318	-4.249	30	.000

	TUM Mean	TWM Mean	Paired Differences					t	df	Sig. (2-tailed)
			Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
						Lower	Upper			
Fraudulent transactions	1.42	2.00	-.581	.886	.159	-.906	-.256	-3.649	30	.001
Confidential information	1.52	2.03	-.516	.890	.160	-.842	-.190	-3.230	30	.003
Client Security Affected	1.39	1.74	-.355	.798	.143	-.647	-.062	-2.476	30	.019
Privacy	1.23	1.77	-.548	1.028	.185	-.925	-.171	-2.971	30	.006
Incorrect use of information	1.26	1.90	-.645	1.330	.239	-1.133	-.157	-2.700	30	.011
Potential fraud	1.23	2.10	-.871	1.056	.190	-1.258	-.483	-4.590	30	.000
Technological differentiator	1.42	2.13	-.710	1.131	.203	-1.125	-.295	-3.493	30	.002
Increase in productivity	1.48	2.03	-.548	1.060	.190	-.937	-.160	-2.882	30	.007
Use of resources	1.42	2.16	-.742	.965	.173	-1.096	-.388	-4.281	30	.000
Quality of service	1.29	2.03	-.742	.965	.173	-1.096	-.388	-4.281	30	.000
Self-confidence in technology	126	1.97	-.710	1.101	.198	-1.114	-.306	-3.588	30	.001
Easy to understand	1.42	1.81	-.387	.919	.165	-.724	-.050	-2.344	30	.026
Easy to use	1.55	2.10	-.548	1.287	.231	-1.020	-.076	-2.373	30	.024
Easy to manage	1.68	2.23	-.548	1.150	.207	-.970	-.127	-2.655	30	.013
Modularity	1.39	2.06	-.677	.909	.163	-1.011	-.344	-4.150	30	.000
Smart keyboard	1.35	1.94	-.581	.886	.159	-.906	-.256	-3.649	30	.001
Sense of curiosity	1.35	2.03	-.677	.909	.163	-1.011	-.344	-4.150	30	.000
Interface design	1.39	2.16	-.774	1.087	.195	-1.173	-.376	-3.967	30	.000
Task masterization	1.35	2.19	-.839	1.128	.203	-1.253	-.425	-4.139	30	.000
Self-esteem lost	1.29	2.13	-.839	.898	.161	-1.168	-.509	-5.200	30	.000
Self-confidence lost	1.26	1.65	-.387	1.022	.184	-.762	-.012	-2.108	30	.043
Psychological confusion	1.23	1.71	-.484	1.122	.201	-.895	-.072	-2.402	30	.023
Aesthetics and functionality	1.35	2.32	-.968	1.080	.194	-1.364	-.572	-4.991	30	.000
Enhanced visibility	1.42	2.06	-.645	1.112	.200	-1.053	-.237	-3.230	30	.003
Increased pleasure	1.58	2.00	-.419	.992	.178	-.783	-.055	-2.353	30	.025

IV. Conclusions

When analysing the results, we identified the factors considered as critical, which could impact on the adoption of ISMD by Mexican users. We believe that this suggests that understanding the phenomenon can contribute to organizations having the adequate IT ISMD development in order to significantly increase their chances of having success in the market place. It is important to mention that these factors could only be used as a guide for Mexican developers of ISM, not as definitive guidelines.

ISMD users can change their perception of a particular ISMD, by creating, eliminating and/or modifying expectations towards the technology. We believe that perception evolves as technology use advances over time. Consequently, it is important that researchers and developers also evolve their models and techniques applied in developing ISMD. Additionally, we argue that it is important that developers look into the research related to the development and use of technologies in order to create better and more efficient information systems.

V. Limitations

Our results are interesting; however, they must be taken with caution. The particular ISMD developed for this research

is of particular/special interest to a Mexican organization. Thus, results could be different if the study is re-created in a different environment; in several organizations or in a different country. There may have been some aspects of ISMD of particular importance to some participants that could have been omitted from this study and which no doubt would have affected the outcome.

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