Australian Journal of Basic and Applied Sciences
2018 December; 12(12): pages 94-103
DOI: 10.22587/ajbas.2018.12.12.16
Original paper
AENSI Publications
Journal home page: www.ajbasweb.com

Factors Affecting the Usability of Laboratory Information System used in Libyan Hospitals by using Technology Acceptance Model (TAM)

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Received date: 15 November 2018, **Accepted date:** 20 December 2018, **Online date:** 31 December 2018

Abstract

Information system research can help the industry improve their service management and coordination via a successful information technology (IT) implementation. Many hospitals have implemented various healthcare IT, such as Laboratory Information System (LIS), in order to deal with paperless and filmless operation requirements. An LIS is necessary to manage the flow of information between health care providers, patients, and laboratories and should be designed to optimize not only laboratory operations but also personalized clinical care. The objecvtive of this study is to analyze and integrate several factors impacting the acceptance and usability of the laboratory information system (LIS) used at Libyan Hospitals. In the light of Technology Acceptance model (TAM), and extending it to seven external variables including computer anxiety, self-efficacy, user interface design, training, age, educational level and system experience. For this purpose, quantitative research was chosen for examining the research model, and the data were obtained from technicians, chemists, and physicians using the Laboratory Information System (LIS). The sample size is (N=250); therefore, the data were analyzed using Structural Equation Modeling (SEM) to analyze the relationship between explanatory factors and actual use of LIS. SmartPLS software was utilized to analyze the data and test the hypotheses. The results indicate that actual use of laboratory information system significantly and positively affected by behavioral intention, education level, interface design, perceived usefulness, perceived ease of use, training, system experience. Moreover, computer anxiety and elder age significantly and negatively affect actual use of LIS. The implications of the outcomes are discussed, and suggestions for future research are made.

Key words: Technology Acceptance Model, laboratory Information System (LIS), perceived usefulness, external variables, perceived ease of use, information technology, medical laboratory, usability.

INTRODUCTION

Information has become a necessity in our daily lives, and now, the information circulation has become easier and faster. Since the information system is bringing about operational ease in almost every field of life it touches, it has a great and solid contribution to our lives. With every passing day, humans are getting more addicted to information to keep themselves informed about what is going on. Slowly but gradually, the technology is getting sharper and sharper; so, we must get ourselves ready to cope with its demands. The main reasons behind the popularity of the information systems are their performances, capabilities and powerful usability (Ahmed, 1991).

Now it is possible to perform more operations using a hand-held device like managing schedules, sending emails, making video calls, and surfing websites. The ease of information system as a source of conveying information faster than any other media source has made it very popular and widely used. The information systems are so prevalent, widely spread and common nowadays that they have turned into an easy source to pass on information quicker than any other media source. An advanced study has been directed to information system application specifically to take notice of the catastrophe avoidance of utilizing Medical Laboratories Software, they turned out to be more solid notwithstanding the most delicate tests.

In this context, the users need more than a well-known company name (Ahmed, 1991). People of different educational levels and ages are using different information systems. The usability of various users depends not only on the deep knowledge and literacy of the user but also on the ease of the screen interface and its easy usability, which keeps the users satisfied.

The attractive mobile phone screen interface with eye-catching interface design puts bearing on the usability as well as on its performance. Some information systems have appealing apparent designs, which became possible by improving the screen interface design and the performance of the user, which contributed to the overall ease of use and a better user experience.

Today, with the rapid enhancement of technology, there has also been a fast development of medical software and systems, which are used in hospitals. These systems can help minimizing errors, reducing costs and improving the service delivery. Governments and private hospitals pay large sums of money to make the most of latest technologies. Recently, usability has become an important consideration for the software design. Particularly, it has been repeatedly

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emphasized in several texts that special purpose information systems should be easily usable so that they can fulfill the purpose, for which, they are designed. Software packages related to medicine and healthcare should be even more easily usable as lives of many people may be affected directly or indirectly by the performance of such systems.

Numerous models have been presented for predicting technology acceptance of a software or information system. One of these models is the Technology Acceptance Model (TAM), which assumes that users' behavior predicts the actual utilization of a system. It is testable and has proven itself as a reliable and cost-effective tool for explaining the behavioral of users using a broad range of technology (Teo, 2009).

Several researches are available on TAM, extended TAM, and the predicting factors affecting the software usage. This study will contribute to the existing litreture because it is the first study of its kind that throws light on the use of extended technology acceptance model in the context of a Libyan healthcare application, which is used in diffrent Libyan medical laboratories.

Despite the increasing usage of healthcare information systems, research on actual use and behavioral intention to use laboratory information system are scarce. The main objective of this empirical study is to fill this gap by investigating the acceptance of laboratory information system and various factors that affect people' preference of LIS use in Libyan Hospitals.

The organization of the rest of the paper is as follows: In the second section theoretical background and hypotheses are provided. The research methodology is explained in the third section. Next, the results of the analysis are provided. The paper concludes with discussion of the findings, directions for future research and theoretical and practical implications.

2. RESEARCH MODEL AND HYPOTHESES

A Technology Acceptance Model will be used in this study, and an extended model will be developed, which will show the effects of external variables such as computer anxiety, self-efficacy, age, educational level, system experience and interface design on the original variables of the TAM model. Perceived ease of use and usefulness show how this effect will relate to the behavioral intentions behind the TAM use, and finally, the extended model will show how all these variables directly or indirectly affect the actual system used in the laboratory, which is illustrated in Figure 1. Questionnaire survey methodology has been used to gather information from the users' rich experience of using the laboratory information system (LIS). An online data collection module was used for collecting data from the different LIS users at Libyan Hospitals Laboratories. The study used structured equation modeling (SEM) and SmartPLS software.

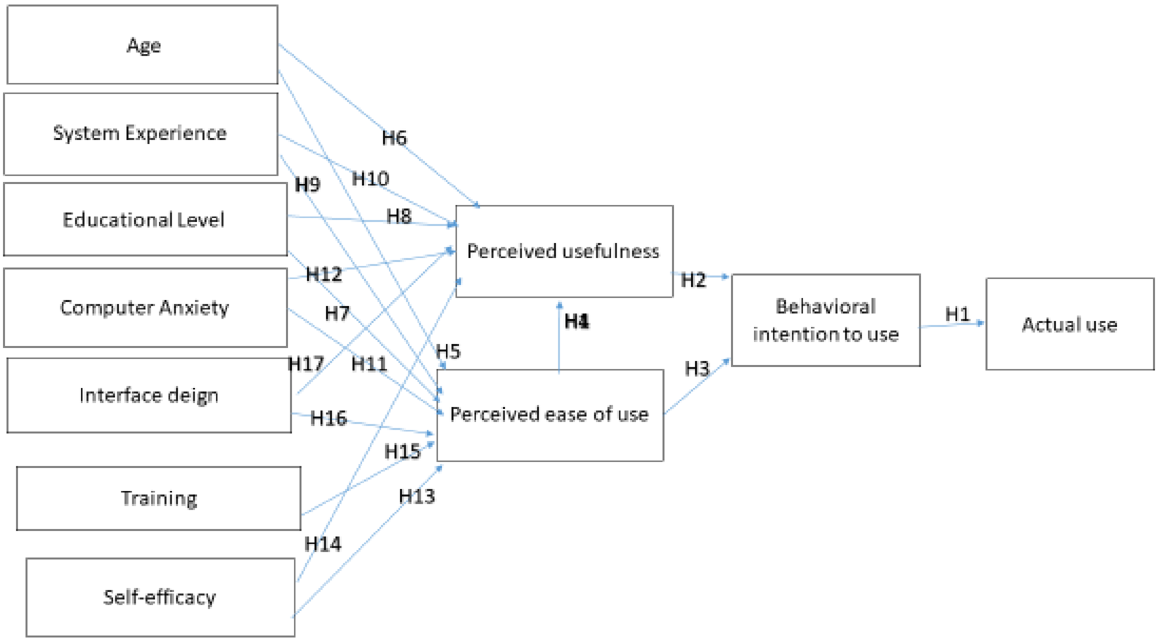

Figure 1. Proposed Research Model

2.1. Actual use (AU).

Like any other information system, Laboratory Information Systems (LIS) collects different types of data; however, some segments of the data are more important. This does not mean that the collected data is more than the requirement. The actual use indicates how an information system was practically used in a specific institution or location. It throws light on the useful user-centric aspects. Understanding the actual use is very important because that helps redesigning, modifying, and re-modifying an information system. Generally, the actual use of an information system can be different as compared to its developers' perspective.

2.2. Behavioral intention to use.

It is significant because it considers motivational factors, which have a behavioral impact. The behavioral intention indicates how much effort people focus on planning and actually exert for performing that behavior (Ajzen, 1991, p. 181). This is obvious because technology users first show intent before actually using the technology. The behavioral intention is a factor that acts as an "immediate determinant" of practical application (Mathieson, 1991); still, behavioral intention is predictable when a person has mixed intention, i.e. either to show or not to show that behavior (Ajzen, 1991). When an employee shows strong intention that he/she will utilize any particular system, that person is likely to try more; so, it will increase the "likelihood of using the system" (Ajzen & Madden, 1986).

According to the current study, utilization of laboratory information system (LIS) is voluntary, so, the users should consider using it in the future as a critical tool.

Based on the mentioned facts, we formed the following hypothesis:

H1: Behavioral intention has a positive impact on actual LIS system usage.

2.3 Perceived usefulness (PU).

PU means the extent, to which, a person thinks that a specific system can improve his/her on-the-job performance in a particular organization; therefore, potential users' intent to use any type of information technology is highly influenced by their perception of usefulness of that system (Davis et al., 1989).

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Investigations by many information system researchers show that "PU is a valid precursor for the prediction of an individual's acceptance" (Venkatesh & Davis, 2000). Furthermore, some studies acknowledge the impact of PU on behavioral intention behind using certain systems (Chin & Todd, 1995). Therefore, we hypothesized:
H2: Perceived usefulness has a positive impact on behavioral intention to use the LIS.
2.4 Perceived ease of use (PEOU)
PEOU represents the extent, to which, a person believes that applying a particular system will be easy in terms of mental and physical effort. Several studies confirm that there is a significant and positive impact of PEOU on behavioral intention, which can be direct or indirect in terms of perceived usefulness (Davis et al., 1989; Agarwal & Prasad, 1999; Jackson et al., 1997; Hu, Chau, Sheng, & Tam, 1999; Venkatesh, 1999; Yi & Hwang, 2003). The current study aims to revalidate this relationship in the Libyan context of LIS use; so, we hypothesized:
H3: Perceived ease of use has a positive impact on behavioral intention to use the LIS.
H4: Perceived ease of use has a positive impact on perceived usefulness of the LIS.

2.5 Age

Several researches show that there is a definitive relation between a user's age and information technology acceptance and usage. Older users do not easily accept and sometimes resist change (Nickel & Pinto, 1986). They consider that the new IT is less beneficial, challenging to learn or difficult to use (Gomez, Egan & Bowers, 1986). Even if they have the willingness to develop IT skills, older workers generally have a tendency to misunderstand or dislike them. According to our prediction, PU and PEOU are precise but they do not act as perfect factors, which define the behaviors of users towards the IT skills. Previous studies by Koufaris (2002) confirmed that user's age has a role in terms of technology acceptance, which is true for most of the new technologies (Chung, Park, Wang, Fulk, & McLaughlin, 2010). Empirical findings by Prasad and Agarwal do not support it; however, they reported that the impact was unclear, and besides, they used "job tenure" in place of age.
H5: Age has a negative impact on the perceived ease of using LIS.
H6: Age has a negative impact on perceived LIS usefulness.

2.6 Educational level

A user's educational level affects his/her success when that person tries to use Information technology (Zmud, 1979). Empirical evidence shows that education results in advantages in terms of technology usage (Davis, 1990). PU and education should be positively linked; however, greater education should improve PEOU because it improves users' attitude towards technology and reduces anxiety (Igbaria, 1989; Lucas, 1978), and when substantial knowledge is provided, it assures adaptive and result-oriented learning (Ashcraft, 2002). Some studies (Legris, Ingham, & Collerette, 2003; Burton-Jones & Hubona, 2006) suggest that the level of education is an individual variable, and it has significant impact on technology acceptance. Hence we will have the following two hypotheses:
H7: Educational level has a direct and positive impact on LIS' perceived ease of use.
H8: Educational level has a direct and positive impact on perceived usefulness of the LIS

2.7 System experience

Several behavioral theories argue that as the IT experience increases, it strengthens the relationship between a person's behavior beliefs, and IT usage. Researches provide ample evidence that there is a significant as well as positive impact of system experience on performance (Venkatesh et al., 2003). Strong and Dishaw Year showed positive relation between IT usage experience and the PU. Prasad and Agarwal discovered positive relation between PEOU and the similar IT experience. Some studies (Burton-Jones & Hubona, 2006) showed that system experience can be habit-forming, so it is an extra effect. Specifically, if a customer has been using a technology for long time, it is likely to become an everyday work tool, and customers and/or users will not think in terms of perceived usefulness/ease of use each time they will use it. It happens mainly because their system experience is likely to generate both PU and PEOU. Hence, we will have the following two hypotheses:
H9: System experience has a direct and positive impact on LIS' perceived ease of use.
H10: System experience has direct and positive impact on perceived usefulness of the LIS.

2.8 Computer anxiety

Anxiety refers to ''evoking anxious/emotional reactions in order to perform a certain behavior" (Venkatesh et al., 2003, p. 432); therefore, less anxious people are likely to become the potential users, and they are likely to interact with the system more often as compared to those people, who feel anxious. Many studies show that anxiety is linked with perceived ease of use (Igbaria & Iivari, 1995; Venkatesh, 2000; Raaij & Schepers, 2008). Venkatesh (2000) researched and claimed that computer anxiety affects a user's sense of perceived ease of use specifically during the initial adoption period. Later, Raaij and Schepers (2008) shed light on the fact that computer anxiety and personal innovativeness directly impact perceived ease of use (PEOU) in a virtual learning environment. Additionally, some important studies (Koufaris, 2002; Venkatesh, 2000; Venkatesh & Morris, 2000; Venkatesh & Bala, 2008) show that computer anxiety is hypothesized as a deeply-held conviction that creates a positive PEOU regarding a particular system. Hence we will have the following hypotheses:
H11: Computer Anxiety has a direct negative impact on LIS' perceived ease of use of the LIS.
H12: Computer Anxiety has a direct negative impact on perceived usefulness of the LIS.

2.9 Self-efficacy

People have certain beliefs regarding their own selves, and their capacities to take certain actions. Everyone believes that he or she can do a few things and cannot do some other things. People develop psychological opinions about the situations they can be put into (Bandura, 1977). On the other hand, self-efficacy shows that people have the confidence that they will be able to use a certain technology. The current study throws light on the importance of users' self-efficacy on the actual usage of computer systems. The people show certain confidence in their abilities to utilize these systems because they influence both an IT system's acceptance and its perceived ease of use (Gong, Xu, & Yu, 2004).

Compeau et al. (1999) believed that self-efficacy can be significant for adapting a computer system during a certain implementation period. In addition, Venkatesh (2000) demonstrated that PEOU \completely mediates the impact of command over computer usage on behavioral intentions.
H13: Self Efficacy has a direct positive impact on LIS' perceived ease of use.
H14: Self efficacy has a direct positive impact on LIS' perceived usefulness.

2.10 Training

Generally, users' expertise/skill and the type of technology used are major factors behind their technology acceptance (Igbaria *et al.* 1995). According to Expectancy theory, when the IT training is provided to users, and they learn an information system, it should be expected that the users will use the information system more conveniently.

Based on the technology acceptance model, it can be stated that the information system training will create belief among users, which will make them conveniently use the information system. The training users ask for help when the information system/technology is taught; so, users get more skillful. Influence training has a definitive impact on PEOU, and many researchers support it including Davis (1989), Venkatesh (2000), Taylor and Todd (1995), and Rouibah *et al.* (2009).

It is an established fact that a user is satisfied and feels the need to use an information system if that system/technology is easy to use.
Based on the mentioned theories and researches that show the impact of training on user-friendliness/ease of use, we can form the following hypothesis:
H15: Training has a direct and positive impact on perceived ease of LIS use.

2.11 Interface design

A user-interface design is another significant factor in terms of increasing usage. Information software with a user-friendly design is another essential matter that needs serious attention (McKnight, Dillon, and Richardson, 1996). A properly designed user interface enables users to operate the system with more convenience because it reduces pressure on their minds (Jones, Surry, and Farquhar, 1995; Mendelsohn and Martin-Michiellot, 2000). Moreover, Venkatesh and Bala (2008) found that the interface design consists of the system and data characteristics, as they are the major PU determinants. System-linked characteristics are the main PU and PEOU determinants. Based on that, we can form the following two hypotheses:
H16: User-interface Design has a positive impact on the perceived ease of LIS use.
H17: User-interface Design has a positive impact on the perceived LIS usefulness.

3. METHODOLOGY

This study has been conducted to examine a user's behavioral intentions and actual Laboratory Information System (LIS) use at Libyan Hospitals. The current study uses the Technology Acceptance Model (TAM), which was presented by Davis (1989), who introduced some external variables to it. We will come up with an extended version of the model that shows relationship among the external variables: Computer anxiety, system experience, self-efficacy, training, interface design, age, system experience, educational level and the TAM variables such as PU and PEOU, so the model might be outstretched to incorporate other external variables related to the usability study.

There are several researches that used TAM and extended TAM for predicting factors affecting software usage, and this thesis will contribute to the existing literature as it will be the first study of its kind that uses extended technology acceptance model in a Libyan healthcare application.

3.1 Data Collection

A questionnaire survey methodology has been chosen to gather data for this research project. Our target audiences were the people who are using the Laboratory Information System (LIS) at different Libyan Medical Hospitals including nurses, technicians, chemists, physicians and consultant physicians.
Survey has been constructed in two segments. The first segment consists of demographics such as age, gender, educational level, experience and LIS usage experience in years. The second segment included questions about the items used. There are 31 items, which measure the actual use, behavioral intention to use, PU, PEOU, self- training, efficacy, computer anxiety, age, system experience and educational level.

After collecting data from 250 respondents, a quick analysis about the demographic information about the participants was conducted. The results of demographic profiles of participants have been shown in Table 1. Overall, 48% participants were women, 52% were men, and the respondents' average age was 27.13 years. Out of them, 8.4% have high school degree, 18.8% have associate degrees, 37.2% were undergraduates, 16.6% have master's degree and 19% were PhD degree holders.

Table 1. Demographic Profile of Respondents

Age (years)		
Max: 63	Min: 23	Average: 42
Gender (%)		
Female: 48	Male: 52	
Educational status (%)		
High school: 8.4	Associate degree: 18.8	Undergraduate: 37.2
Master's degree:16.6	PhD degree: 19	
Job *(%)*		
Nurse: 6.4	Technician: 54	Chemist: 2.4
Physician: 26	consultant physician: 11.2	
Computer Experience ***(years)***		
1 - 2 Years: 30	3 - 5 Years: 19	6 - 10 Years :42
More than 10 years: 159		
Weekly Computer use in hours		
1 - 5 Hours :66	6- 10 Hours: 54	More than 10 hours: 130
System experience (Months)		
1-12 *Months:35*	13-24 *Months:62*	25-72 *Months:98*
More than 72 *Months:55*		

The items of the constructs are shown in Table 2. They were adapted from the questionnaires of previous researches listed in the table. The only survey has been sent to the target group and the data collection was completed during January 2018. The items were arranged in the form of a 5-point Likert scale, in which, one represents "strongly disagree" and five represents "strongly agree."

Table 2. Constructs, Items and References

Construct	Code	Reference	Items
Actual use (AU)	AU1	Li & Chang (2008)	I use the Laboratory Information System in my work routinely.
	AU2	Li & Chang (2008)	I am interested in using the Laboratory Information System (LIS) for my future work.
	AU3	Li & Chang (2008)	My several routine matters are accomplished with the help of the Laboratory Information System.
Behavioral intention to use (BI)	BI1	Park and Cheong (2005)	I have intention of using LIS software system.
	BI2	Park and Cheong (2005)	I have intention of using Laboratory software system as much as possible.
	BI3	Park and Cheong (2005)	I recommend LIS software to others.
Perceived	PU1	DAVIS (1989)	LIS helps me quickly accomplish the tasks.

Usefulness (PU)	PU2	DAVIS(1989)	Laboratory Information System increased my output.
	PU3	DAVIS(1989)	Using Laboratory Information System improved my job performance.
	PU4	DAVIS(1989)	Using Laboratory Information System improves my on-the-job effectiveness.
	PU5	DAVIS(1989)	Laboratory Information System makes my job easier.
	PU6	DAVIS(1989)	Overall, I believe that the LIS is useful for my job.
Perceived ease of use (PEOU)	PEOU1	DAVIS (1989)	Learning Laboratory Information System is easy.
	PEOU2	DAVIS(1989)	Operating the Laboratory Information System is easy.
	PEOU3	DAVIS(1989)	I have clear and understandable interaction with the Laboratory Information System.
	PEOU4	DAVIS(1989)	Becoming a skillful Laboratory Information System user was easy for me.
	PEOU5	DAVIS(1989)	Overall, the Laboratory Information System is easy for me.
Computer Anxiety (ANX)	ANX1	Venkatesh et al. (2003)	I have apprehensive feeling about using the Laboratory Information System
	ANX2	Venkatesh et al. (2003)	I feel scared that I might accidently lose important information while operating the Laboratory Information system by mistakenly pressing the wrong key.
	ANX3	Venkatesh et al. (2003)	I feel hesitation to use the Laboratory Information system because I might make mistakes that I might not be able to correct.
	ANX4	Venkatesh et al. (2003	To me, the Laboratory Information system is somehow intimidating.
Computer Self-Efficacy (SE)	*SE1*	Kijsanayotin, Pannarunothai and Speedie (2009).	I could use Laboratory Information System software in my work if I had used similar technologies before.
	SE2	Kijsanayotin, Pannarunothai and Speedie (2009).	I will be able to use Laboratory Information System software in my work if I get its user *support.*
	SE3	Kijsanayotin, Pannarunothai and Speedie (2009).	I can use Laboratory Information System software in my job but I need training for that.
	SE4	Kijsanayotin, Pannarunothai and Speedie (2009).	I can use the Laboratory Information System software in my work if the user manual is provided to me.
User Interface design (UID)	UID1	Meng Chang Chen, Fan Liu, Yeali S. Sun, Chin-Hwa Kuo, David Wiblec (2010).	The Laboratory Information System layout design makes it easy to read**.**
	UID2	Meng Chang Chen, Fan Liu, Yeali S. Sun, Chin-Hwa Kuo, David Wiblec (2010)	The layout, font style, and color of the interface make me read it easily.
	UID3	Meng Chang Chen, Fan Liu, Yeali S. Sun, Chin-Hwa Kuo, David Wiblec (2010)	Generally, I feel satisfied with the Lab software interface design.
Training (TR)	TR1	Li & Chang (2008)	My skills of using are helpful to operate how to use the Laboratory Information System (LIS).
	TR2	Li & Chang (2008)	My skills of using the Laboratory Information System (LIS) are helpful to use other softwares.
	TR3	Li & Chang (2008)	The knowledge I obtained from Laboratory Information System (LIS) enables me to save time while learning further.

3.2 Statistical analysis

Structural Equation Modeling is a statistical method to analyze the link between independent and dependent variables (Ulucan, 2018; Bayraktar et al., 2016). SEM consists of two important stages. First, causal processes are represented by a series of regression equations. Secondly, in order to better understand the relationships being tested, structural relationships are created pictorially (Byrne, 2011). SEM aims to identify whether the created theoretical model is supported by available data. Also this model uses hypothesis testing to test theoretical models and thus determines the relationships among constructs (Schumacker & Lomax, 2012). There are two types of variables in the SEM. These are latent and observed variables. The observed variables are variables that are measured by means of measurement tools and have quantitative results. Latent variables are variables that express an abstract concept on their own and are explained by observed variables. In the current study, the PLS-SEM method has been applied with the SmartPLS 3.2.7 software. SmartPLS is one of the prominent software applications for Partial Least Squares Structural Equation Modeling (PLS-SEM). It was developed by Ringle, Wende & Will (2005).

4. RESULTS

4.1. Measurement model

In this paper, we applied confirmatory factor analysis (CFA) for testing reliability as well as validity of the concerned seventeen constructs including: Actual use, behavioral intention to use, perceived ease of use, perceived usefulness (PU), self-efficacy, training, computer anxiety, age, system experience and educational level. The reliability and validity of the constructs were analyzed by convergent and discriminant validity. The convergent validity was measured by factor loadings, Cronbach's alpha, Construct Reliability, and Average Variance Extracted. CFA was applied to test the factor loadings. The measurement model's effectiveness lies in its reliability as well as validity. Each item's factor loading of the constructs is more than 0.6 which falls within the acceptable range. The results of confirmatory factor analysis are shown in Table 3.

Table 3. Confirmatory Factor Analysis

CONSTRUCT	Code	**Sample Mean (M)**	**Standard Deviation (STDEV)**	**Factor loading**	**T Statistics (|O/STDEV|)**
Computer anxiety	ANX1	0.906	0.023	0.909	38.693
	ANX2	0.716	0.048	0.714	14.993
	ANX3	0.889	0.013	0.888	70.428
	ANX4	0.916	0.021	0.919	44.605
Actual use	AU1	0.934	0.017	0.936	55.806
	AU2	0.904	0.038	0.911	24.192
	AU3	0.933	0.022	0.934	41.713
Age	AGE	1.000	0.000	1.000	
Behavioral intention	BI1	0.873	0.050	0.884	17.676
	BI2	0.762	0.088	0.786	8.912
	BI3	0.869	0.018	0.862	48.071
Educational level	EL	1.000	0.000	1.000	

Perceived ease of use	PEOU1	0.779	0.045	0.784	17.566
	PEOU2	0.740	0.044	0.748	17.173
	PEOU3	0.852	0.019	0.851	44.346
	PEOU4	0.811	0.022	0.813	36.549
	PEOU5	0.741	0.058	0.750	12.864
Perceived usefulness	PU1	0.704	0.028	0.699	25.206
	PU2	0.807	0.038	0.814	21.495
	PU3	0.787	0.035	0.792	22.887
	PU4	0.858	0.021	0.861	41.709
	PU5	0.714	0.027	0.709	26.086
	PU6	0.792	0.041	0.800	19.659
Self-efficacy	SE1	0.667	0.035	0.666	19.172
	SE2	0.896	0.014	0.897	62.612
	SE3	0.808	0.021	0.809	38.042
	SE4	0.640	0.067	0.651	9.777
Training	TR1	0.901	0.012	0.901	73.234
	TR2	0.834	0.022	0.835	37.200
	TR3	0.681	0.046	0.683	14.855
User Interface design	UID1	0.759	0.040	0.761	18.940
	UID2	0.854	0.022	0.855	39.470
	UID3	0.754	0.044	0.761	17.255
System experience	SYS	1.000	0.000	1.000	

Cronbach’s alpha shows level of internal consistency and construct reliability shows how well the allocated items measure a construct. In other words, Cronbach's Alpha measures the reliability value of every construct that Table 4 shows. Each construct has a reliability value, and it is clear that all the reliability values exceed 0.7, which means that they exist within the acceptable range. For measuring convergent validity, we test composite reliability and calculate the Average Variance Extracted (AVE). The AVE, which indicates the convergence of items, values of each construct. Table 4 clearly indicates that the mentioned measures are consistent and reliable. It can be seen that all the composite reliability values are above 0.7, which means that they are all within the acceptable range. In addition, Table 4 shows that every construct has AVE value exceeding 0.50, which lies within the acceptable range at $p < 0.005$ significance level.

Table 4. Construct Reliability and Validity

	Cronbach's Alpha	**Composite Reliability**	**Average Variance Extracted (AVE)**
AGE	1.000	1.000	1.000
AU	0.918	0.948	0.859
BI	0.808	0.882	0.714
ANX	0.880	0.919	0.742
EL	1.000	1.000	1.000
PEOU	0.849	0.892	0.625
PU	0.872	0.903	0.610
SE	0.758	0.845	0.582
SYS	1.000	1.000	1.000
TR	0.732	0.851	0.659
UID	0.704	0.835	0.629

After calculating the composite measures, discriminate validity was assessed, which applies when an item weakly relates with all the constructs other than the one, with which, it is theoretically correlated. For a good discriminant validity, the diagonal elements represented the square root of AVE should be greater than non-diagonal elements represented the correlations among constructs in the same row and column. Garson (2009) believed that discriminate validity is possible to achieve if the correlation with the concerned variable is high. Table 5 shows implied correlations between the variables. These results support the discriminate validity of the studied model.

Table 5. Discriminant Validity

	AGE	**AU**	**BI**	**ANX**	**EL**	**PEOU**	**PU**	**SE**	**SYS**	**TR**	**UID**
AGE	1.000										
AU	0.068	0.927									
BI	0.133	0.819	0.845								
ANX	-0.146	-0.236	-0.401	0.862							
EL	0.730	0.241	0.357	-0.170	1.000						
PEOU	0.298	0.483	0.607	-0.523	0.448	0.790					
PU	-0.091	0.500	0.571	-0.607	-0.026	0.642	0.781				
SE	0.097	0.401	0.418	-0.492	0.094	0.575	0.639	0.763			
SYS	0.391	0.348	0.466	-0.404	0.374	0.525	0.438	0.427	1.000		
TR	0.376	0.267	0.401	-0.349	0.386	0.600	0.358	0.493	0.426	0.812	
UID	0.206	0.399	0.482	-0.533	0.307	0.608	0.575	0.645	0.390	0.434	0.793

4.2 Structural model and hypotheses testing

We used PLS-SEM through Smart PLS 3.2.7 to test the hypotheses. Table 6 summarizes the standardized parameters and the calculation of t-values to measure each indicator’s weight significance (Hair et al., 2013).

Table 6. Path Coefficients

Path	**Standard Deviation**	**T Statistics**	**P Values**	**Standardized Path Coefficient (β Coefficient)**

Age -> PEOU	0.057	2.863	0.004	-0.164
Age -> PU	0.052	3.523	0.000	-0.185
BI -> AU	0.021	38.190	0.000	0.819
Computer anxiety -> PEOU	0.062	2.640	0.009	-0.162
Computer anxiety -> PU	0.047	5.067	0.000	-0.238
Educational level -> PEOU	0.057	5.485	0.000	0.314
Educational level -> PU	0.060	3.886	0.000	-0.234
PEOU -> BI	0.086	4.732	0.000	0.408
PEOU -> PU	0.068	6.067	0.000	0.415
PU -> BI	0.075	4.120	0.000	0.309
Self-efficacy -> PEOU	0.051	3.525	0.000	0.180
Self-efficacy -> PU	0.061	2.764	0.006	0.168
System experience -> PEOU	0.060	2.543	0.011	0.154
System experience -> PU	0.054	2.990	0.003	0.160
Training -> PEOU	0.047	5.457	0.000	0.254
User interface -> PEOU	0.062	2.770	0.006	0.172
User interface -> PU	0.059	2.277	0.023	0.135

As shown in Table 7, almost all the hypotheses are accepted or supported except for hypothesis 8, as the current findings have revealed that educational level doesn't have a direct and positive impact on perceived usefulness of the LIS. It may be related to the respondents themselves, as their educational level might have no role in recognizing the perceived usefulness; however, other variables/constructs, for example, user interface and self-efficacy were found to be significant for increasing the PU.

Table 7. Summary of Hypotheses

Item	Path	Hypotheses	Supported
H1	BI->AU	Behavioral intention to use has a positive impact on actual system usage.	Yes
H2	PU->BI	Perceived usefulness has a positive impact on behavioral intention to use.	Yes
H3	PEOU->BI	Perceived ease of use has a positive impact on behavioral intention to use.	Yes
H4	PEOU->BI	Perceived ease of use has a positive impact on perceived usefulness.	Yes
H5	Age-> PEOU	Age has a negative effect on perceived ease of use.	Yes
H6	Age-> PU	Age has negative impact on perceived usefulness.	Yes
H7	Educational level -> PEOU	Educational level has a direct and positive impact on perceived ease of use	Yes
H8	Educational level -> PU	Educational level has a direct and positive impact on perceived usefulness.	No
H9	System experience -> PEOU	System experience has a direct and positive impact on perceived ease of use.	Yes
H10	System experience -> PU	System experience has a direct and positive impact on perceived usefulness	Yes
H11	Computer anxiety -> PEOU	Computer anxiety has a direct and positive impact on perceived ease of use	Yes
H12	Computer anxiety -> PU	Computer anxiety has a direct but negative impact on perceived usefulness	Yes
H13	Self-efficacy -> PEOU	Self-efficacy has a direct and positive impact on perceived ease of use	Yes
H14	Self-efficacy -> PU	Self-efficacy has a direct and positive impact on perceived usefulness	Yes
H15	Training -> PEOU	Training has a direct and positive impact on perceived ease of use.	Yes
H16	User interface -> PEOU	User-interface design has a positive impact on the perceived ease of use of the LIS	Yes
H17	User interface -> PU	User-interface design has a positive impact on perceived usefulness of the LIS.	Yes

Table 8 provides the values of R Squared and R Square adjusted. R-squared is mainly used as a statistical tool for revealing proportion of the variance of a dependent variable(s) explained by the independent variable(s). Specifically, R-squared is a descriptive statistical tool showing values between 0 and 1. R-squared value 1.0 means perfect fit; so, if its value is closer to 1, it means a good statistical model (Li & Parker, 2008). Thus, the assessment of the current statistical model was carried out by the R-squared (R^2) as revealed in Table 8. In fact, it can be seen that we obtained R Squared values such as value of R Squared of AU (R^2=0.671), R Squared of BI (R^2=0.424), R Squared of PEOU (R^2=0.618) and R Squared of PU (R^2=0.689). It approximates 67% of changes in the dependent variable, which can be attributable to the AU. The same trend can be realized in the other independent variables, especially in BI (42%), PEOU (62%) and PU (69%). Indeed, the proportion of the variance for AU was found to be 67%, BI was 42%, PEOU was 62% and PU was 69%, which shows significant changes in the dependent variables. Figure 2 displays the standardized path coefficients with their corresponding variables

Table 8. R-square Values

	R Square	R Square Adjusted
AU	0.671	0.670
BI	0.424	0.419
PEOU	0.618	0.607
PU	0.689	0.680

Citation: Said Milad Mohmed Rabha, *et al.*, Factors Affecting the Usability of Laboratory Information System used in Libyan Hospitals By using Technology Acceptance Model (TAM). Australian Journal of Basic and Applied Sciences, 12(12): 94-103. DOI: 10.22587/ajbas.2018.12.12.16

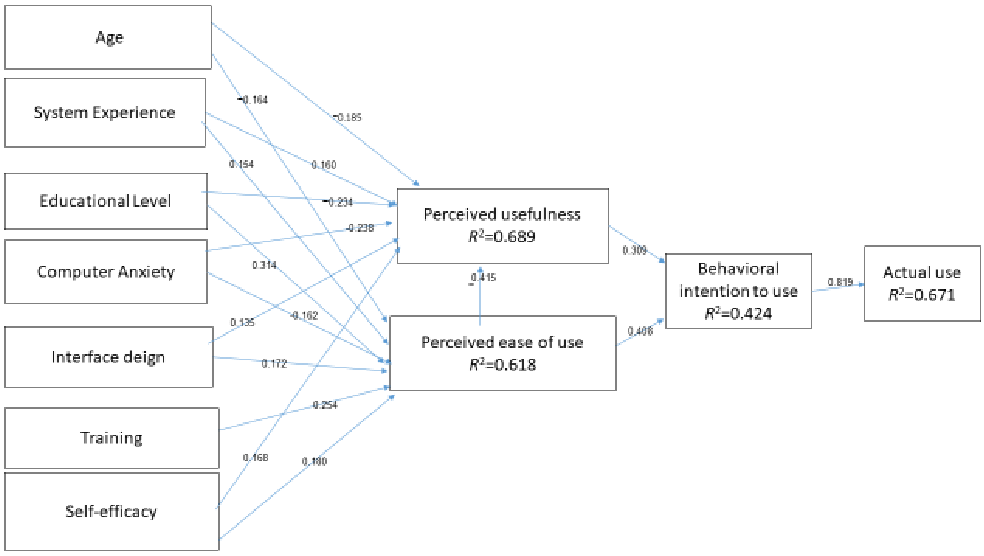

Figure 2. Research Model with Results

4.3 Direct and indirect effects:

The findings presented in Table 9 clearly show that the actual use of LIS is just affected by the workers' behavioral intention to use (0.819), because this direct effect is statistically significant at 0.05 level; however, other independent variables including age (0.119), computer anxiety (0.132), educational level (0.079), perceived usefulness (0.253), perceived ease of use (0.439), system experience (0.108), self-efficacy (0.121), training (0.112) and user interface design (0.110) have indirect effects on the actual use because all the direct effects are sgnificant at 0.05 level. From exogenous and endogenous perspectives, it can be noticed that all the exogenous variables including age, system experience, educational level, computer anxiety, interface deign, training and self-efficacy indirectly affect the actual use. While two endogenous variables including perceived useful and ease of use have indirect effects on actual use; however, the behavioral intention to use is stand-alone endogenous variable that directly affects the actual use.

Table 9. Direct, Indirect and Total Effects

Dependent variable	Independent variables	Direct effects	Indirect effects	Total effects
Actual use	AGE	-	-0.119*	-0.119*
	BI	0.819*	-	0.819*
	ANX	-	-0.132*	-0.132*
	EL	-	0.079*	0.079*
	PEOU	-	0.439*	0.439*
	PU	-	0.253*	0.253*
	SE	-	0.121*	0.121*
	SYS	-	0.108*	0.108*
	TR	-	0.112*	0.112*
	UID	-	0.110*	0.110*

*: p<0.05.

5. IMPLICATIONS AND CONCLUSIONS

5.1. Theoretical and practical implications

In the past years, several research has studied on the elements that impact the successful laboratory information system implementation. Researchers have done many studies on the end-users' approach, application areas of healthcare information systems (Idoga et al., 2018; Maamari and Chaainine, 2018., Handayani et al., 2017).

The current study was fundamentally designed to find out the effects of some exogenous variables including age, system experience, educational level, computer anxiety, interface deign, self-efficacy, training, and certain endogenous variables including perceived ease of use (PEOU) and perceived usefulness (PU) on the actual use (dependent variable). Overall, our findings are based on testing 17 hypotheses and they are consistent with findings of previous studies (Venkatesh & Davis, 2000; Davis, 1985; Davis, Bagozzi, & Warshaw, 1989); therefore, our understanding of user acceptance processes plays a significant role in providing new successful design perspectives and information systems implementation (Davis, 1985). In the following paragraphs, we'll compare the findings of our study with previous studies.

According to this study, age has negative effect on PU (-0.185) and PEOU (-0.164). That means that the outcomes of the current study indicate that when people/customers become older, their technology acceptance becomes poorer. This result is consistent with the findings of previous studies (Koufaris, 2002), which showed that age influences technology acceptance models for different technologies (Wang, Fulk, Chung, Park, & McLaughlin, 2010).

Moreover, it has been shown that system experience has a positive impact on PU (0.160) and PEOU (0.154). This finding indicates that customers' more system experience leads to substantial technology use. The results of this study agree with the ones obtained during the earlier observational studies (Burton-Jones and Hubona, 2006). These studies indicate that system experience results in habit formation. Specifically, if the customer uses a technology for long time, that tool is more likely to become a routine tool; so, the customers won't need to assess its PU or even PEOU mainly because of the direct effect of the system experience, which is likely to raise both PU and PEOU.

Furthermore, an interesting finding was educational level that has two different effects. First, the educational level has a positive effect on the PEOU (0.314); however, it has a negative impact on the PU (-0.234). This result is simultaneously similar and different from the correlations mentioned by Hubona and Burton-Jones (2006). They demonstrated that the educational level positively and significantly affects the PEOU; however, it is somewhat surprising that it has negative effect on the PU. This result is inconsistent with the results of other studies (Legris, Ingham, & Collerette, 2003; Burton-Jones & Hubona, 2006) that suggests that the level of education is seen as an individual variable and it is proved to have significant effects on the technology acceptance; however, the negative effect of the educational level on the perceived usefulness can be considered as a new finding that needs further and deeper investigation.

Conversely, the most obvious finding to emerge from the analysis is that the computer anxiety negatively affects both PU (-0.238) and PEOU (-0.162). These findings were somewhat expected given the fact that other researches (Venkatesh, 2000; Venkatesh & Morris, 2000; Koufaris, 2002; Venkatesh & Bala, 2008) show that computer anxiety is hypothesized as a deeply-held belief, which doesn't create a positive perception of a system that it is easy to use; therefore, the current findings agree with the findings of such studies. Venkatesh and Bala (2008) found out that experience neutralizes the impact of computer anxiety that increases PEOU.

Another interesting aspect of this data is that it shows that the interface design plays a role in forming a positive perception of ease and perception of usefulness (PEOU and PU) (0.172 and 0.135). It is encouraging to compare this result with the findings of Venkatesh and Bala (2008) who found that the interface design consists of the system-related and information-related characteristics. The former is the major determinant of PEOU while the later is a major determinant of PU. Despite the significance of interface design, Venkatesh and Davis (1996, p. 451) believe: "Trainings, which are focused on improving users' computer self-efficacy, can be more useful than the improved interface design in terms of enhancing user acceptance."

In addition, the current findings revealed that training positively affects the PEOU (0.254). Thus, our results agree with previous studies (Venkatesh & Davis, 1996; Burton-Jones & Hubona, 2006; Venkatesh & Bala, 2008), which have demonstrated that training helps enhancing information technology uses or adoption. A main reason behind effective system training is the utilization of diverse training modes, which improve different determinants of information technology adoption. For example, game-based training showed better results than the traditional training because it enhances user acceptance of new systems. Moreover, it positively affects PEOU that improves users' behavioral intention to use a technology (Venkatesh & Bala, 2008). Finally, training is useful because it helps developing favorable perceptions of different PU and PEOU determinants among users. The current study also supports the idea that training should be imparted to make potential users form favorable perceptions of both PU and PEOU (Legris et al., 2003; Venkatesh & Bala, 2008).

Moreover, self-efficacy positively affects both PU (0.168) and PEOU (0.180). These results are in accordance with many recent studies (Holden & Rada, 2011; Legris et al., 2003; Mun & Hwang, 2003; Park, 2009; Venkatesh & Bala, 2008) indicating that computer self-efficacy significantly determines both PEOU and PU. Venkatesh (2000) showed that PEOU raised the level of computer self-efficacy so well that it significantly affected the users' behavioral intention.

Additionally, the current study demonstrated that both the PU (0.309) as well as PEOU (0.408) positively affects behavioral intention to use. Similarly, we found that PEOU positively affects perceived usefulness (PU) (0.415). In the nutshell, the findings show that perceived ease of use (PEOU)) more significantly affects behavioral intention to use as compared to the perceived usefulness (PU). The last part of the current model showed that behavioral intention to use positively affects the actual use (0.819). This finding mirrors findings of the previous studies (Park, 2009; Park, Nam, & Cha, 2012; Pavlou, 2003; Szajna, 1996), which investigated the technology acceptance model in terms of users' behavioral intentions. Such studies have provided ample evidence that PU and PEOU are significant in terms of affecting users' intention to use a technology. As PU is a significant predictor of users' behavioral intentions, so, the findings of our study enhanced the relevant literature that shows very high correlation between intentions and actual use (Szajna, 1996).

In conclusion, this study has developed an extended model for investigating and predicting those factors, which affect the laboratory information system (LIS) usability in Libyan Hospitals,by integrating the concepts of users' actual use, behavioral intention to use, beliefs and some external variables. The structural equation modeling (SEM) technique has been applied for examining the mentioned model. The study has provided valuable and acceptable results that could be used for improving the laboratory information system (LIS) usability. These results are significantly supported by previous studies. In addition, the negative effect of the educational level on the perceived usefulness can be considered as a new finding that needs to be investigated more deeply while other proposed hypotheses were found to be significantly supported, which provided us with a unique understanding of respondents' acceptance of the laboratory information system (LIS) in Libyan Hospitals.

5.2. Limitations and Future work

Even though the current study and its findings contribute to better understanding of the factors, which affect the actual use of laboratory information system (LIS) in the Libyan hospitals, there are a few limitations in this study that provides an opportunity for future work. First of all, the current results are not generalizable to the wider population such as private hospitals or clinics since the sample was obtained from a public hospital located in Libya. The results may differ if the model is retested in a different hospital/group of hospitals located in another country with a different culture.

Next, demographic information was collected through the survey, which was partially used in the proposed research model. During a future research, in addition to age, educational level, system experience, and demographic characteristics including gender, employment status and other information should be collected and incorporated in the model. Finally, although some dependent variables are explained, only 67% of the actual use has been explained in the proposed model. Hence, as a future research, further constructs may be taken into account that play important role for explaining actual usage of internet-based educational tools.

ACKNOWLEDGEMENTS

I acknowledge the continuous support from the Kastamonu University, Turkey, and also feel thankful to the Libyan Government for funding my stay and education in Turkey. I feel thankful to the professors of the IT Department, Kastamonu University, for their useful feedback and encouragement.

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