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Original Article

Usability Evaluation of Laboratory Information System by the Model of Usefulness, Satisfaction, and Ease of Use (USE)

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Abstract

Introduction: Laboratory information system (LIS) is one of the key components of healthcare information system (HIS). It can help the healthcare providers to delivery faster, easier, and more efficient healthcare services. Acceptance and success of LISs depend on the appropriate designs of user interface of these systems. Therefore, this study was conducted aiming to focus on the end-user usability evaluation of LIS.

Methods: This is a descriptive cross-sectional study. It was conducted on the LIS embedded into a HIS used in Faghihi Hospital affiliated to Shiraz University of Medical Science, Iran. The target population was all of 80 pathologists and laboratory technicians of this hospital who worked with LIS. We used the questionnaire of Usefulness, Satisfaction, and Ease of Use (USE) to evaluate the LIS. The descriptive data were analyzed using SPSS22; the reliability and validity of the measures and model were determined using Smart-PLS version 3 with Partial Least Squares.

Results: The result of all the constructs with regard to USEQ model demonstrated a positive effect of "Usefulness" (t-value=2.08), "Satisfaction" (t-value=1.89) and "Ease of use" (t-value=5.05) on the usability of the LIS.

Conclusion: The USEQ model proposed was a valid and reliable instrument and could be used by researchers. The LIS was usable, and end-users could interact with this system without any effort. Therefore, healthcare professionals can perform their tasks better with this system and make appropriate diagnostic and therapeutic decisions for their patients.

Keywords: Laboratory information system, LIS, Usability, Evaluation, USEQ Model

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Introduction

Information technology and computer science have been used in different industries, specialty healthcare(1). In the health field, these systems are recognized as healthcare information systems (2). They can help the providers to delivery faster, easier, and more efficient, secure, and accurate healthcare services (1). Laboratory information system (LIS) is one of the key components of healthcare information systems. It facilitates the physician's access to more effective and efficient data for developing care decisions, performing interventions and communicating the results with other providers (3).

Acceptance and success of LISs depend on the appropriate designs of these systems (4, 5). The poor design of the user interface is one of the reasons that affect the users' interaction with the LIS and leads to problems while working (6-8). Therefore, it is very crucial to detect and resolve these problems (9). Usability testing as a critical tool can be used for identifying these problems (10, 11). The International Organization for Standardization (ISO) 9241 defines usability as "the extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use" (12-15). Usability evaluation has been demonstrated to be effective in identifying the existing problems, saving time in the development of the software, and decreasing human errors, medical errors, and patient length of stay and costs (16, 17).

There are several types of testing methods for the usability evaluation of these systems (18). Despite the fact that many studies applied these methods to different healthcare information systems including health information system (1, 19-21), nursing information system (2, 22), admission and medical records (23, 24), obstetrics and gynecology information system (25), radiology information system (26, 27), and computerized provider order entry system (16, 28), there is a lack of information about usability of laboratory information systems(LISs). Therefore, this study was conducted aiming to focus on the end-user usability evaluation of laboratory information system using Usefulness, Satisfaction, and Ease of use (USE) Questionnaire. Also, the present study provided a new model for usability evaluation of healthcare information systems.

Methods

Study Setting

This is a descriptive cross-sectional study conducted in 2017. This study was conducted on the LIS embedded into a HIS used in Faghihi hospital affiliated to Shiraz University of Medical Science, Iran. Routinely, about 400 daily active users interact with this system. Through the LIS, the physicians' orders are sent to the laboratory department. Technicians receive orders via this subsystem and enter the results to be communicated in response to the physicians' orders. The target population consisted of 80 pathologists and laboratory technicians of this hospital who worked with LIS.

Usability Instrument

The instrument used to evaluate LIS was the Usefulness, Satisfaction, and Ease of use Questionnaire (USEQ). The USEQ is one of the usability evaluation techniques to measure the systems' efficiency and effectiveness (29). The questionnaire of the study consisted of two parts: demographic questions and usability construct questions. The first part of the research contains demographic questions of the respondents including age, sex, marital status, and education level, job title, LIS experience, and computer skills experience. In addition, this research used USEQ to measure the usability of laboratory information system, which consists of 30 items aiming at addressing three usability characteristics of a system: (1) Usefulness, (2) Ease of Use, and (3) Satisfaction. A five-point Likert-type scale ranging from (1)"strongly disagree" to (5) "strongly agree" was used to answer the questions.

Proposed Model

Some of the usability models have been identified such as Eason Model (1984), Shackel Model (1991), Nielsen Model (1993), ISO 9241-11(1998), ISO 9126 (2001) and QUIM model (2006). In this paper, we used a model extracted from USE Questionnaire. This model is appropriate for novice users that have little knowledge of usability and can be applied by usability experts and non-experts. USEQ model consists of 3 factors (Figure 1). The limitation of this model is that it is not optimal yet and needs to be validated.

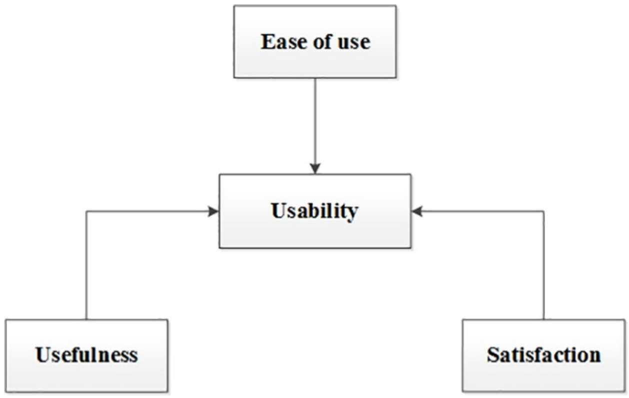

Figure 1: USEQ Model

Hypotheses Formulation

In this section, research hypotheses are presented on the basis of the relationships between the USEQ model constructs and usability. These relationships are shown in Figure 1.

H1. Usefulness will positively affect Usability of the LIS.
H1. Ease of Use will positively affect Usability of the LIS.
H1. Satisfaction will positively affect Usability of the LIS.

Data analysis was conducted using SPSS 22.0 and SmartPLS 3.0. The validity of the proposed constructs for this model was approved using a confirmatory factor analysis method and Structural Equations Modeling (SEM). The Smart PLS was used to test the model. This software is used to analyze the multi-construct data.

Result

Descriptive Analysis about Respondent Demographics

Respondent roles: There were 80 responses to the survey. Of the total responses, 74 were analyzed. Eight respondents (10.8%) were laboratory technicians, 41 (55.4%) were laboratory experts, and 18 (24.3%) were pathologists. The remaining participants were residents, processing technicians, and laboratory supervisors (7, 9.5%).

Education level: Eight (10.8%) respondents had an College Degree, 33 (44.6%) Bachelor, 15 (20.3%) Master's, and 18 (24.3%) Ph.D.

Sex: Forty three (58.1%) respondents were female and 31 (41.9%) male.

Marital status: Twenty-six (35.1%) respondents were single and 48 (64.9%) married.

Age: Eighteen (24.3%) respondents were younger than 30, 34 (45.9%) were 30–39 years of old, 18 (24.4%) were older than 40, and four respondents did not give their age.

LIS experience: Most respondents (64.9%) reported having LIS experience and 26 (35.1%) had not used LIS before.

Computer skills experience: Just over half of the respondents (67.5%) reported that they had experience of working with computer and the others did not work with computer.

Years of using the laboratory information system: Most respondents (50%) reported using LIS for 5 or more years. Thirty (40.5%) of them had used LIS for <5 years, and seven respondents did not give the information.

Reliability and Validity of the Measures and Model Measurement Model

In this section, the relationships between the components of each construct with the construct were evaluated through Internal Consistency Reliability, Convergent validity, and Discriminant validity.

Internal Consistency Reliability

Traditionally, "Cronbach's alpha" is used to measure the internal consistency reliability in social science research, but it tends to provide a conservative measurement in PLS-SEM. The reliability of the attributes in the questionnaire using Cronbach's Alpha was 0.97 with 30 items. Cronbach's Alpha was used to check the reliability of each construct. The results showed that all constructs in the questionnaire were reliable because they were above 0.5.

Convergent Validity

There are three items for assessing Convergent validity including factor loading, Average Variance Extracted (AVE), and Composite Reliability (CR). To check the convergent validity, each latent variable's factor loading, AVE, CR were evaluated. The acceptable threshold for loading were set at >0.5; the AVE should be >0.5 and CR should be >0.7 (30). From Table 1,

Table 1: Measurement Model

Construct (attribute)	Item	Loadings Weight	Cronbach's Alpha	AVE	CR
Usefulness	Q1	0.754049	0.927027	0.667638	0.940735
	Q2	0.710220			
	Q3	0.875825			
	Q4	0.868200			
	Q5	0.934185			
	Q6	0.892766			
	Q7	0.800625			
	Q8	0.660703			
Ease of use	Q9	0.753943	0.936667	0.614079	0.945722
	Q10	0.767800			
	Q11	0.770397			
	Q12	0.831180			
	Q13	0.710055			
	Q14	0.793093			
	Q15	0.686477			
	Q16	0.800700			
	Q17	0.768246			
	Q18	0.869314			
	Q19	0.849173			
Satisfaction	Q24	0.870535	0.946713	0.759948	0.956627
	Q25	0.725925			
	Q26	0.889740			
	Q27	0.887972			
	Q28	0.908548			
	Q29	0.901499			
	Q30	0.903631			
Usability	Q20	0.956318	0.960314	0.893577	0.971085
	Q21	0.941005			
	Q22	0.937787			
	Q23	0.945954			

Table 2: Discriminant Validity

	Ease of use	Satisfaction	Usability	Usefulness
Ease of use	1.000000			
Satisfaction	0.837987	1.000000		
Usability	0.801988	0.743193	1.000000	
Usefulness	0.815788	0.768744	0.731988	1.000000

Table 3: Hypothesis Testing

Hypothesis		Path coefficient	t-value	Result
H1	Usefulness will positively affect Usability of the LIS	1850.	082.	Confirmed
H2	Ease of Use will positively affect Usability of the LIS	4950.	5.05	Confirmed
H3	Satisfaction will positively affect Usability of the LIS	1850.	1.89	Confirmed

it can be seen that the results of the measurement model exceeded the acceptable threshold values that indicate sufficient convergence validity.

Discriminant Validity

The discriminant validity is a supplementary concept. two criteria were mentioned for that: Fornell-Larcker method and transverse load test (27). Fornell and Larcker (1981) suggest that the square root of AVE in each latent variable can be used to establish discriminant validity if this value is larger than other correlation values among the latent variables (31). To do this, a table was created in which the square root of AVE was manually calculated and written in bold on the diagonal of the table. The results in Table 2 shows that all values in diagonal were greater than those in the row and columns on the particular constructs. It was shown that the measures discriminant are distinct.

Structural Model

After confirming the validity and reliability of the model, the determined structural model was evaluated. The structural model demonstrates the correlation or causal dependencies of the measurement model in the study. Table 3 and Figure 2 present the structural model analysis. The result of R^2 values showed that the predictive power of the model including three dependent constructs was acceptable and indicated that the theoretical model explained a substantial amount of the variance in performance. R^2 was estimated 0.671, which shows that this model could measure the usability at a high level. Therefore, the appropriateness of the model was desirable. The value of Q^2 was estimated 0.601, which indicated the sufficient predictive relevance of the model. In addition, the path estimates and t-statistics were calculated for the hypothesized relationships (30). The t-value was compared with the error level

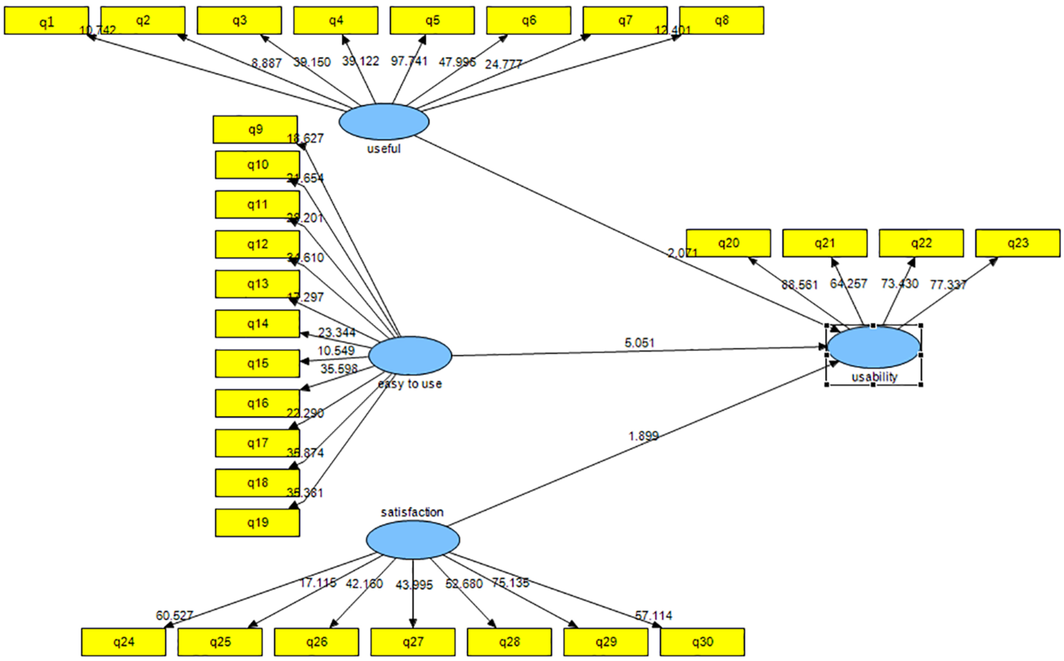

Figure 2: Analysis Model

to assess the relationship between dependent and independent constructs (32). Where the values are greater than the minimum of 1.64 (32, 33), all relationships were confirmed.

Discussion

Usability is an important factor for the success of the interactive computerized systems (34, 35). Several methods have been proposed to support the usability evaluation of these systems. These methods are different based on their complexity, applicability, development cycle, advantages and disadvantages (26, 36). The present study was designed to determine the effect of a conceptual model, which can be used for evaluating the usability of healthcare information systems in developing countries. To this aim, the literature on the information systems and importance of usability evaluation were investigated. Then, the research hypotheses were introduced based on theoretical foundations. These hypotheses were checked by confirmatory factor analysis and Smart PLS software.

Two indicators should be considered to confirm or reject these hypotheses. The first indicator is the path coefficient which represents the strength and direction of the relationship between the constructs. The positive path coefficient indicates a direct relationship and the negative path coefficient shows an indirect relationship. The second indicator is the t-value. The t-values assess the relationship between dependent and independent constructs based on the error level. At the error level of 0.01%, 0.05%, and 0.1%, path coefficients with a minimum of 2.58, 1.96, and 1.64 in t-value are confirmed (32). The findings shown in Table 3 reveal that the t-value for all hypotheses with an error level of 0.05 were greater than 1.96. Based on this indicator, all hypotheses were confirmed.

In this study, the path coefficient of H1 hypotheses was 0.185 and the t-value after the coefficient test was 2.08. Based on research model proven in the significance level $\alpha<0.05$ standard, the usefulness has a positive influence on Usability; H1 hypothesis of this study is established. Usefulness is “the degree to which a person believes that using a particular system would enhance his or her job performance” (37, 38). Studies have shown that information systems must be designed based on the users’ requirements and expectations; otherwise, they will not be accepted by users and will be at risk of failure (2, 20, 21). When the user interface design is compatible with the users’ workflow, it can be useful and helps to better interact with the system. This is in line with the findings of Yen and Dhouib (2, 17, 34), which showed that the design of the information systems must be matched with the users’ tasks, and support them.

As the results of this study, the path coefficient of H2 hypotheses was 0.495 and the t-value after the coefficient test was 5.05. Based on the research model proven in the significance level $\alpha <0.05$ standard, the Ease of use had a significant positive influence on Usability; H2 hypothesis of this study was established. Ease of use is described as “the degree to which a person believes that using a particular system would be free of effort” (37, 38). The convenience and ease of the use of information systems help the users to quickly get the work skills with the system and facilitate their routine work. These findings recommend that an appropriate interface design can improve the user performance and reduce the complexity of these system (2).

Another important finding of this study, the path coefficient of H3 hypotheses was 0.185 and the t-value after the coefficient test was 1.89. Based on the research model proven in the significance level $\alpha <0.05$ standard, satisfaction had a positive influence on Usability; H3 hypothesis of this study was established. Satisfaction refers to subjective response to how users are comfortable to use the information systems or websites and their positive attitude after using them (30). The usability of the interface of the information system is considered as one of the key factors that affect the user satisfaction (10, 19, 39). In addition, user satisfaction is a factor that influences information system success (40).

Finally, a number of important limitations need to be considered. First, the number of participants in this study was based on the recommended sample size for usability studies, but it is still relatively small. Moreover, usability in current study was evaluated by the user-based method, while expert-base methods such as heuristic can be useful for the evaluation of laboratory information system. These methods are used by usability evaluators without the involvement of the end-users for identifying the problems of the systems. Future studies should investigate these methods.

Conclusion

In conclusion, this study investigated the connections among the attributes for LIS usability. Based on the findings, the design of this LIS is usable and end-users can interact with this system without any effort. Therefore, healthcare professionals perform their tasks better with this system and make appropriate diagnostic and therapeutic decisions for patients.

In addition, the purpose of this study was to design a model for usability evaluation of the healthcare information systems. The present results indicated that the USEQ model proposed was a valid and reliable instrument and could be used by researchers. Three constructs of this model (usefulness, ease of use and satisfaction) were considered as determinant factors in usability evaluation of LIS. The impact of all three constructs on usability has been confirmed. These results enable us to generalize the USEQ instrument and enhance its robustness as a valid measure of evaluating usability.

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Authorship

Both authors have contributed equally to this study.

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