International Journal of Pure and Applied Mathematics
Volume 117 No. 15 2017, 1001-1014
ISSN: 1311-8080 (printed version); ISSN: 1314-3395 (on-line version)
url: http://www.ijpam.eu
Special Issue

ijpam.eu

Software usability datasets

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Abstract- Usability of software systems have recently become a very significant quality factor for enhancing the quality of software and is usually associated with easiness in use and learn. A various usability models and ISO/IEEE standards have been proposed in literature with their own set of features and attributes. The proposed models are validated using a number of qualitative usability evaluation techniques. However, there is a lack of a commonly used, standard dataset for usability evaluation. In this work, two new datasets i.e. software development lifecycle (SDLC) and Live Auction are created and made publicly available. Moreover, in this paper, we have also done a critical analysis of usability evaluation techniques and use questionnaire evaluation technique to create the new datasets.

Keywords: software usability, evaluation techniques, questionnaire, dataset, SDLC, live auction.

1. INTRODUCTION

The demand for the quality of software systems is increased exponentially in recent years. Software usability has been an essential quality factor, and the literature review shows that the usability study for a software process can predict the success or failure of any software product. Usability [5] is an extent of which a software product can be used to achieve some specified goals with effectiveness, efficiency, and satisfaction."

Usability Engineering(UE) can be defined as "the systematic approach to improving the usability of user interfaces by applying a set of proven methods throughout the system development lifecycle" [14]. A number of intermediate levels are executed repeatedly according to the active user participation in developing a software product using UE model. Majorly, the usability estimation plays a major role in the Evaluation level of UE as the level has been executed by evaluation team, who is in charge of assessing the results which are obtained by applying usability

evaluation technique on the existing interactive system. Hence, the Evaluation level does the critical changes in the development of software system, enabling designers and developers to incorporate user feedback until an acceptable level of usability is reached.

Usable software systems are much more successful as they are more accurate, safe, efficient, and effective. A literature review has shown the various advantages of incorporating usability in the software development process. Hence, usability evaluation has become a significant research area. However, there is a lack of commonly used, a standard dataset of usability. Many researchers propose different usability models, but none of them defined the usability dataset for usability evaluation. In the last few decades, various researchers have defined and proposed some software usability evaluation techniques. The software usability evaluation techniques can be decomposed into the following three categories i.e. inspection, testing, and inquiry. Any usability evaluation method may be chosen for usability evaluation as per the available resources, types of users, abilities of the evaluator, and the environment. This research defines and creates the two-new dataset for usability evaluation and presents the comparative analysis of the software usability evaluation techniques.

In the following section, some of the related software usability evaluation techniques has been discussed and compared using five different criteria. Later on, in section 3, the methodology for two-new dataset (Software development life cycle models and live auction) using usability issues has been discussed followed by conclusion and references.

2. Software Usability Evaluation Techniques

The usability evaluation can be categorized into 3 main categories i.e. Inspection, Testing, and Inquiry. Inspection evaluation can be defined as the examination of documentation that serves of evidence that control is in place. The inquiry is the process of collecting the information directly from a person, who is an expert in the subject matter.

To be effective, The Qualitative Usability Evaluation Technique returns the detailed information about the system S instead of just returning “yes/no” or a number as an answer. The detailed information that is returned by the evaluation technique consists of (a)what will be the main usability problems that real users will find when interacting with system S; and (b)why the design of a given system S did not work as anticipated. Hence, the main goal of the qualitative usability evaluation

process is to generate the usability value alongwith a prioritized list of usability problems for system S.

Many of the qualitative usability evaluation techniques are focused on analyzing the interface of a particular interactive system (see e.g. [14,29,30,31]). These techniques can be applied successfully for evaluating system softwares, but the technique become very complex when there are large number of systems related to the same context of use as the information in the large number of systems must be visualized and processed simultaneously. Therefore, as per the qualitative viewpoint, to diagnose the general usability problems as a whole is the most challenging for UE nowadays. Identifing such type of problems can help (1)to prevent usability errors when a novel interactive system is being developed; and (2)to evaluate a new interface belonging to this context. Nevertheless, qualitative usability evaluation processes need to focus on the prioritizing the ''what'' over the ''how many/how much'' type question related to the usability problems.

Here, we are highlighting only the main evaluation techniques from each category.

A. Inspection Techniques

Inspection evaluation can be defined as the examination of documentation that serves of evidence that control is in place. This qualitative usability evaluation technique includes many methods like Cognitive Walkthrough, Pluralistic Walkthrough, Heuristic Evaluation, Perspective-Based Inspection, Formal Usability Inspection, Consistency Inspection, and many more. Here we have only discussed the most common methods.

Cognitive Walkthrough

According to [19], the cognitive walkthrough is based on a task methodology that concentrates on user's actions and checks whether it supports the effective accomplishment of the task. In simple term, Cognitive Walkthrough defines as "an expert simulates users problem solving"[19].

Heuristic Evaluation

According to [13], a number of examiners are given a task and asked them to judge whether its design elements follows a set of defined usability heuristics i.e. Flexibility, Documentation, Prevention of errors, Efficiency, and Help. In simple term, Heuristic Evaluation defines "an expert identifies violations of heuristics"[13].

B. Testing Techniques

The Testing technique includes many methods like Thinking Aloud Protocol, Shadowing Method, Coaching Method, Teaching Method, Log File Analysis, Remote Testing, and many more. Here we have only discussed the most common methods.

Thinking Aloud Protocol

According to [14], the participants are asked to verbalize their opinions and thoughts while interacting with the software system. There are two variants for this i.e. periodic and critical response. In simple term, "user talks during test"[14] in Thinking Aloud Protocol.

Remote Testing

According to [23], participants and testers are separated in time and space. It may be different place different time or, same place different time depending on the requirement. In simple term, "tester and user are not collocated during test"[23] in Remote Testing.

Metrics for Usability Standards in Computing (MUSiC) Method

According to [10], MUSiC has tools for measuring user satisfaction and performance. The four major aspects of MUSiC are Usability Analysis, Cognitive Workload Measurement, Satisfaction Measurement, and User Performance Measurement.

C. Inquiry Techniques

The inquiry is the process of collecting the information directly from a person, who is an expert in the subject matter. This qualitative usability evaluation technique includes many methods like Contextual Inquiry, Field Observation, Focus Groups, Interviews, Surveys, Questionnaires, User Feedback, and many more. Here we have only discussed the most common methods.

Field Observation

According to [15], testers visits the user's area and observe their thought process which the users have the task or interface. It also includes user's interviewing about how they use the product. In simple term, "interviewer observes system use in users environment"[15] in Field Observation.

Questionnaires

According to [18], it is a series of questions and collects the user's response. Its main focus is on assessing the software system according to the factors that are essential for usability. For example, WAMMI (Website Analysis and Measurement Inventory), SUMI (Software Usability measurement inventory) etc. In simple term, "user provides answers to specific questions"[18] in Questionnaires.

D. Comparative Analysis of Evaluation Techniques

According to [21], the comparative analysis of the software usability evaluation methods is based on 7 criteria, i.e. can conduct remotely (Yes/No), Expensive (Yes/No), Intrusive (Yes/No), Applicable Stages and Usability issues covered (Effectiveness, Efficiency, Satisfaction). Table 1 presents the comparative analysis of the usability evaluation techniques.

Table 1: comparative analysis of usability evaluation techniques

Usability evaluation technique **Criteria**	*Cognitive Walkthrough [19]*	*Heuristic Evaluation [13]*	*Remote Testing [23]*	*Thinking Aloud Protocol [14]*	*MUSiC Method [10]*	*Field Observation [15]*	*Questionnaire [18]*
Can be conducted remotely	No	Yes	Yes	No	No	No	Yes
Intrusive	No	No	No	Yes	Yes	Yes	Yes
Expensive	No	No	Yes	Yes	Yes	Yes	No
Applicable Stages	Design, Coding, Testing, Deployment	Design, Coding, Testing, Deployment	Design, Coding, Testing, Deployment	Design, Coding, Testing, Deployment	Testing, Deployment	Testing, Deployment	Design, Coding, Testing, Deployment
Usability issues covered	Effectiveness	Efficiency, Effectiveness	Efficiency, Satisfaction, Effectiveness	Effectiveness, Satisfaction	Efficiency, Satisfaction, Effectiveness	Effectiveness, Satisfaction	Effectiveness, Satisfaction

3. Dataset for Software Usability using questionnaire

A data set is a collection of discrete, related items of related data that may be accessed in combination or individually or managed as a whole entity. The term data set is first originated with IBM, which considers it as a file. Here, we will now describe the methodology for the creation of the dataset on the basis of the three usability issues [22] i.e. effectiveness, efficiency, satisfaction, and their 11 attributes. The attributes of these three factors are given in Table 2. The taxonomy of these 3 usability issues is discussed in [22].

Table 2: Attributes associated with the usability issues.

Usability Issues	Attributes
Efficiency	Resource time, user effort, economical cost.
Effectiveness	Task accomplishment, operability, extensibility, reusability, scalability.
Satisfaction	Likeability, convenience, aesthetics.

Aim & Objective:

The aim and objective of the research are to investigate the usability evaluation of the two datasets viz 'Software Development Lifecycle' and 'live auction' from the viewpoint of students.

The specific objectives of the research are:

- To ask usability experts and students and to give the answers to the questionnaire given to them for software development life cycles, and for the live auction.
- To use the answers given by usability experts and students, compute the values of usability attributes (weights).
- To use the weights of usability attributes and probability theory, compute the total weights of usability issues.
- Usability issues are used as an input to probability theory and compute the final values using the equation f_{val}.

Participants/Sample:

The participants chosen for the survey were usability experts, faculties, and undergraduate students enrolled as engineering students related to two branches (Computer Science and Engineering, and Information Technology) at one of the universities in India. Three batches were selected from each branch. The total number of students was 396. Unusable responses, which were 109, were primarily related to incomplete information. The six SDLC models and live auction web application were evaluated by six classes (three batches from each branch). Demographic information concerning the students is shown in Table 3.

Table 3: Research participants for the conducted survey

		Branches		
		CSE	IT	Total

Sex	Male	105	73	178
	Female	53	56	109
Computer Experience	< one year	3	8	13
	From one to three years	144	104	248
	> three years	11	17	28
Internet Experience	< one year	16	12	28
	From one to three years	75	62	137
	> three years	67	55	112
Frequently Use of Internet	Daily	78	34	112
	Weekly	45	37	82
	Monthly	33	47	80
	By Semester	2	1	3
	Yearly	0	0	0

Why is Questionnaire used?

Questionnaires are effective means of collecting huge amounts of information from an enormous sample of people. When the questionnaires are completed, then data can be gathered relatively quickly. This is helpful for huge populations and when the interviews would be impractical. There is an issue with a questionnaire that is participants may lie due to any reasons. Generally, people want to reflect their positive image, so they bend the reality to reflect the good image. The significant distinction is between open and closed-ended questions. Generally, questionnaire uses both open and closed questions to gather data. And it is productive for collecting both quantitative and qualitative data. The answers to the closed questions can be put into categories, which have been selected in advance by researchers. Such type of data is called as nominal data. Open questions enable people to exhibit what they generally think in their own words.

The following section discusses the methodology for the creation of two datasets using questionnaire:

A. Software Development Life Cycle dataset

Generally, Each Software development life cycle have the following five phases;

1. Understanding or characterize the given problem via requirements gathering.
2. Deciding an execution plan for a solution via Designing.
3. Coding or implemented the planned solution.
4. Testing the actual programs.
5. Deployment & maintenance of the product.

For large systems, methodologies and procedures are needed for efficiency and accuracy as each activity can be of the system is extremely complex. Furthermore, each activity must be broken into smaller steps. Some activities are executed during the software development and some other activities are executed after the completion of software development.

We have employed a questionnaire to generate a dataset for the following six software development lifecycle models.

1. Build & Fix Model[24]

The developer in this model adopts an adhoc[24] approach. Developer builts the software product as many times until it satisfies the client. Build & Fix model requires less experience and less project planning to execute. This method is suitable for very small software.

2. Waterfall Model[25]

This model is also known as classical lifecycle model and it is one of the oldest process model described by Rocye[25] in 1970. Waterfall model is suitable for software projects where we have well known requirements at earlier stages.

3. Evolutionary Model[27]

A prototype[27] can be evolutionary or throwaway. Prototype model is developed to determine the actual need of the client. After completion of software requirement the developer attempts to use existing program segments from prototype and actual system is then developed using waterfall approach to produce good quality software product.

4. RAD Model[25]

The RAD(Rapid Application Development) is a high speed adaption of waterfall model. In this model, a number of teams work on a single function and then it is integrated to form whole software.

5. Iterative Model[27]

If a customer requires changes in its product, then incremental model[27] or iterative model can be used. The previous models discussed earlier do not take into consideration changes in product. The waterfall and prototype model delivers a complete operational product while iterative model delivers an operational quality product at each release.

6. Spiral Model [28].

Spiral model[28] takes risk analysis into software development. In this model, the main aim is to identify high risks related to the software project and resolve it before it threatens the software operation or cost.

Based on systematic and detailed literature review and the information gathered through the experts using questionnaire, the above mentioned six SDLC models are analyzed using the three usability issues, i.e., efficiency, effectiveness, and satisfaction.

Procedure:

Data were gathered using the survey in a university in India where all experts, faculties, and students had access to the Internet. The survey session began with the welcome message to the participants/researcher and explaining the objectives of the study; the SDLC models that would be evaluated; the number of a survey that needed to be filled in; and participants' right to withdraw from the session at any time. The participants were then asked to fill in the pretest questionnaire to get their background and research experience. Then, the participants were asked to provide their perceptions of the usability attributes (values in the form of 0 and 1) using the survey. On the basis of the result of a survey conducted, all the 11 attributes are assigned a value either '0' or '1' as seen in Table 4. If any of SDLC model that includes the attribute in it assigns a value 1, and if a model excludes the attribute from it, then it assigns the value 0.

Using the detailed analysis of SDLC models, the values of the three usability issues can be mapped on the scale of 0-9 using probability as shown in Table 5. The intuition of chance and probability develops at very

early ages [20]. The probability of an event tells that how likely the event will happen. The F_{val} can be computed by finding the probability using the equation (1) and (2):

$$P(factor) = \frac{Number\ of\ favorable\ attributes\ in\ a\ factor\ whose\ value\ is\ 1}{\text{Total number of attributes in a factor}} \quad (1)$$

F_{val} = P(Factor) * M_{val} of mapping scale (2)

Where
P(factor) is the factor probability.
F_{val} is the factor value for the dataset.
M_{val} is the maximum scale value.

Table 4: Values of each attribute for the listed six SDLC model.

Attributes	Build & Fix	Waterfall	Evolutionary	RAD	Iterative	Spiral
Resource	*0*	*0*	*1*	*1*	*1*	*1*
Time	*0*	*1*	*0*	*0*	*0*	*0*
User Effort	*0*	*0*	*1*	*1*	*0*	*1*
Economic Costs	*0*	*1*	*1*	*1*	*0*	*0*
Likeability	*0*	*1*	*0*	*0*	*1*	*1*
Convenience	*0*	*0*	*1*	*1*	*0*	*0*
Aesthetics	*0*	*0*	*1*	*0*	*1*	*1*
Task accomplishment	*0*	*0*	*1*	*1*	*1*	*1*
Operability	*1*	*1*	*1*	*1*	*1*	*1*
Extensibility	*0*	*1*	*0*	*1*	*0*	*0*
Reusability	*0*	*0*	*0*	*1*	*0*	*1*
Scalability	*0*	*1*	*1*	*0*	*0*	*1*

Table 5: Normalized mapped values of the usability issues for SDLC models on the scale of (0-9)

SDLC Models	Effectiveness	Efficiency	Satisfaction
Build & Fix	*1.8*	*0*	*0*
Waterfall	*5.4*	*4.5*	*3*
Evolutionary	*5.4*	*6.75*	*6*
RAD	*7.2*	*6.75*	*3*

Iterative	*3.6*	*2.25*	*6*
Spiral	*7.2*	*4.5*	*6*

B. Live Auction

The auction is a process that marks the presence of a number of interested parties engaging in a bidding war for an item, valuable or service. In the present age of computers, it would be unfair to ask an individual to leave the comfort of their respective premises and be available at a common location. It would also not be apt to ask individuals to involve in the process of the auction by physical gestures when same can be achieved by the click of a mouse. Thus, Live Auction takes this plight of bidding individuals into consideration and makes the process automated. This not only allows the individuals to easily get involved in the process of the auction but also makes the process visually more attractive and informative. The server, controlled by auction administrator, displays all the information needed by the administrator for proper conduction of the process. The client, used by individuals engaging in a bidding war, enables them to be well informed about the player that is up for the auction, including all the stats available to the player, and helps them make a much more informed decision. The client interface also shows the ratings of individual players among the available players, to help the client make a well-informed decision rather than one based on hunches.

Procedure:

Data were gathered using the survey in a university in India where all expert, faculties, and students had access to the Internet. The survey session began with the welcome message to the researcher participants and explain them the objectives of the study; the web application that would be evaluated; the number of a survey that needed to be filled in; and the participants' right to withdraw from the session at any time. The participants were then asked to fill in the pretest questionnaire to get their background and research experience. Then, the participants were asked to provide their perceptions of the usability attributes (weights) using the survey.

Figure 1: Likert 7-point scale.

On the basis of the result of a survey conducted, all the 11 attributes are assigned a value on the Likert 7-point scale as seen in Table 6.

Using the detailed analysis of Live Auction, the values of the three usability issues can be mapped on the scale of 0-9 using probability as shown in Table 7. The intuition of chance and probability develops at very early ages [20]. The probability of an event tells that how likely the event will happen. The $Factor_{value}$ can be computed by finding the probability using the equation:

$$F_{val} = (\sum \text{attributes value in a factor} * M_{val}) / (\text{total no of attributes} * M_{val\text{-of-Likert-scale}})$$

Where
F_{val} is the factor value for dataset.
$M_{val\text{-}of\text{-}Likert\text{-}scale}$ is the maximum likert scale value.
M_{val} is the maximum scale value.

Table 6: Values of each attribute for the live auction

Factors	Attributes	Explanation	Live Auction
Efficiency	**Resource**	It is a resource-related usability attributes for successful completion of the tasks by the users.	**6**
	Time	It is the capability of the software product in term of time invested for activities which includes time spent on errors, response time by the system, and memory Load.	**7**
	Economic cost	it includes all the expenses required for software product.	**5**
	Documentation	It involves requirements which identifies capabilities, characteristics, attributes or qualities of a system. It is the background foundation for what will be implemented.	**1**
	User Effort	It is the capability of a software product for computing the desired outputs with respect to the user's physical and mental efforts.	**6**
Effectiveness	**Task accomplishment**	It is related to the user, who can perform/execute the given tasks with successful accomplishment of the specified goals.	**6**
	Operability	It is related to the task completion with accuracy, help user to perform required functionalities with accuracy.	**6**
	Extensibility	It is the adaptation of software product with respect to changing needs of the user.	**4**
	Reusability	It is the usability measure, such that a software product can be reused in another application.	**5**
	Scalability	It is the ability of software product to continue to function well when the software's volume and size is changed.	**4**
Satisfaction	**Likeability**	It is a measure of a software system to maintain the attention of all kinds of user.	**5**
	Convenience	It is a measure of a software product that builds a strong attitude of the user towards its design.	**5**
	Aesthetics	It is a measure of a software system to attract its user in sensorial terms.	**5**

Table 7: Normalized mapped values of the usability issues for Live Auction on the scale of (0-9)

SDLC Models	Effectiveness	Efficiency	Satisfaction
Live Auction	*6.42*	*5.82*	*6.42*

4. Conclusion

In this research, we have studied various software usability evaluation methods that have been proposed by various researchers along with an analytical comparison of these evaluation methods and created two new datasets. It has been found that the software usability evaluation method has their own benefits and limitations. Either one or more of these evaluation methods may be chosen for usability evaluation of a software system. Here in this paper, we have used questionnaire evaluation technique to create the two-new dataset i.e. software development life cycle dataset and live auction dataset. Both the datasets are created and made publicly available to evaluate its usability.

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