Identifying Usability Risk: A Survey Study

Jayaletchumi T. Sambantha Moorthy, Suhaimi bin Ibrahim, Mohd Naz'ri Mahrin
Advanced Informatics School,
Universiti Teknologi of Malaysia (UTM)
Kuala Lumpur, Malaysia.
tsmjayaletchumi2@live.utm.my, suhaimiibrahim@utm.my, mdnazrim@utm.my

***Abstract*—As defined in various quality models, usability is recognized as an important attribute of software quality. Failing to address usability requirements in a software product could lead to poor quality and high usability problems in software product. Research is still in progress to introduce the best methods for reducing usability problems and increase the rate of successful usable software products. Studies have shown that problems in software products can also be controlled using Software Risk Management methods, even though these problems cannot be eliminated totally. Using Software Risk Management, problems in software products are dealt before it occurs. This paper presents usability problems as a risk factor and by managing usability risk at earlier phases of the development process, successful and high usability software products can be developed. Unfortunately, currently there is little effort in identifying, analyzing and prioritizing potential usability risks at earlier phases of the development process. This paper focuses on usability risk identification as it is the first stage in usability risk management. This paper presents the results of an industry survey based on the opinion of Malaysian Public Sector involving sample size of 330 software developers and software projects managers regarding potential usability risk that could occur during Software Development Life Cycle (SDLC). Our finding has identified 42 potential usability risks, defined as a list for further risk analysis in future.**

Keywords*—usability; usability risk; risk management; risk identification.

I. INTRODUCTION

Usability is one of the significant factors of software product quality [1]. The most referenced usability standard, ISO 9241-11: Guidance on Usability [2] 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". Lack of emphases on usability elements in a software product leads to various usability problem that eventually contributes to the failure of the software product. Generally, usability problem is perceived as an aspect of the system and/or a demand on the user which makes it unpleasant, inefficient, onerous, perturbing or impossible for the user to achieve their goals in typical contexts of use [3].

Reducing usability problems in a software product after its development is very challenging and it is not recommended because of cost and time factor [4]. Hence, usability problems should be overcome during software products development.

Usability problems are considered as a risk factor in development of usable software product and using risk management, potential usability risks can be defined at earlier phases of the development process before risk control activities could be implemented. Currently, development team is facing challenges in predicting usability risks earlier in the development process due to lack of efforts in identifying, analyzing and prioritizing usability risks.

This paper puts forward a survey to identify potential usability risk during SDLC, taking software developers and software project managers in Malaysian Public Sector as the respondents. We present a list of potential usability risk during SDLC. Project managers, quality managers, risk management team and the software development team may benefit by ensuring identified usability risks are eliminated in each phase of software development lifecycle. This contributes to development of more usable and productive software product.

II. RELATED WORK

The concept of risk management has been a popular approach in non-software domain for several decades and it has been adopted in the software domain since the last few years [5, 6]. Using risk management concept, risk can be identified, analyzed, prioritized, mitigated and controlled [7]. This paper concerns research on risk identification steps as it is the initial step in the risk management process.

A. Risk Identification

The objective of risk identification is to determine the risk that may affect a project or product. Early identification of risk helps in minimizing and preventing the effects of the risk. Risk can be identified using techniques such as interview, brainstorm, assumption analysis, survey, voluntary reporting, decomposition, utilization of risk taxonomies and critical path analysis [8].

Risk identification using interview is used when selected experienced project managers or experts in the field are involved. Their experiences will provide adequate information in identifying risk [9] . The drawback of this

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technique is it time consuming. Besides interview, brainstorming is an alternate technique used to identify risk. It is followed when a group of respondents are involved together to generate ideas or find a solution for a specific problem [10]. It needs detailed planning and could be hassled. Other risk identification techniques include Delphi, time a fact-finding, checklist and diagram techniques [11, 12]. The Delphi technique involves selecting experts and their anonymous participation in reaching consensus on a subject such as project/product risk [13]. The Delphi technique can reduce single influence on the outcome and can reduce preconception as well, but it is a costly technique.

Survey is also a popular technique to identify risk. Generally the survey is used to identify the probability of occurrences of selected risk. Survey was utilized to analyze 133 projects in the process of risk identification [14]. Even though this technique is time consuming, it contributes to the completeness of the outcome.

Other techniques which are used to identify risks are observation, and documentation analysis [15], Strengths, weaknesses, opportunities and threats (SWOT) analysis [16], Fault Tree Analysis (FTA), Event Tree Analysis (ETA), Hazard and Operability study (HAZOP) and Failure Mode Effect Analysis (FMEA) [17], use of tools, providing risk scenario or risk description and applying continuous and early identification method [18].

B. *Usability Risks*

The search for the term 'usability risk' shows that this term is not widely used. The term 'usability risk' was first introduced and used in studies involving of e-commerce and World Wide Web services in 1999 [19]. Some studies on mobile application had used this term in their studies as it involves extensive involvement of user [20-22].

Usability risk can be understood as potentially a chosen action or activity lead to an undesirable outcome or loss which could affect usability of a software product. An occurrence of usability risk could develop negative user experiences and leads to software product failure [20]. Many scholars investigate usability problem in their studies and not on usability risk. Usability problem can be perceived as a risk factor in producing usable software product since it is a threat to an optimal user experience [23, 24] where else user experience, in general includes many aspect such as human factors, design, ergonomics, Human Computer Interaction (HCI), accessibility, marketing as well as usability.

Fig. 1 summarizes usability problem as a risk factor for producing usable software product and any effort to identify usability risk can be achieved by taking usability problem as the usability risk factor.

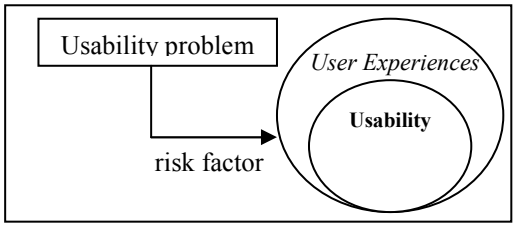

Fig 1. Usability problem as risk factor

III. RESEARCH DESIGN

A. *Research Questions*

This study has one research question as stated below.

What are the usability risks that occur during SDLC?

This research question is intended to identify potential usability risks by empirically validate through survey the occurrences of usability risk during SDLC.

B. *Research Methods*

To answer the research question, a survey was carried out. A questionnaire was constructed with usability risk factors that were derived from usability attributes and sub attributes defined in software quality models [25]. This questionnaire was distributed to 330 respondents consist of software developers and software project managers from Malaysian Public Sector.

Respondents are chosen from Malaysian Public Sector because it was reported in a survey by Malaysian Administrative Modernization and Management Planning Unit (MAMPU) in 2011 that usage of online services in government is only 40% of the overall online services provided and this shows users are exposing to higher usability problem in using online services. This environment is adequate and sufficient to verify usability risk factors identified from software quality models.

Data from survey are then analysed to obtain potential usability risk factors that have been agreed by the respondents as important factor that shows the occurrence of usability risk.

C. *Survey Design*

- *Recruiting Respondents*

  Survey respondents were chosen among software developers and software project managers who have experience in software development process and responsible in dealing with risks during software development. Respondent is recruited from 23 ministries and Malaysian Administrative Modernization and Management Planning Unit (MAMPU) in Malaysian Public Sector. MAMPU is included in this survey as it is the responsible government agency to oversee the functions of administrative modernization and human resource planning for the public sector.

- *Developing Questionnaire*

  The questionnaire was designed based on seven stages provided in [26]: identify the research objectives, identify and characterize the target audience, design the sampling plan, design and write the questionnaire, pilot test the questionnaire, distribute the questionnaire, and analyze the results and write a report.

  It is structured in two sections, A and B. Section A contains questions on demography of the

respondents such as ministry, gender, age, service scheme, experience in software development and knowledge on usability practices in software development.

Section B lists 38 various usability risk factors which could contribute to usability risk. These usability risk factors were derived from usability attributes and sub attributes stated in Table I. This is aligned with the idea that factors affecting the quality of software can be identified from attributes defined in software quality models [4]. Usability attributes used for the purpose of constructing the questionnaire are *Effectiveness*, *Efficiency*, *Satisfaction*, *Comprehensibility* and *Safety* with attribute *Effectiveness* consists of nine questions, *Efficiency* with seven questions, *Satisfaction* with seven questions, *Comprehensibility* with nine questions and *Safety* with six questions. Respondents are also given opportunity to express their suggestion on potential usability risk.

Five point Likert scales are provided for each usability risk factors in the questionnaire: s*trongly agree, agree, neither, disagree and strongly disagree*, with '1' representing *strongly disagree*, and '5' representing s*trongly agree* [27]. Each usability risk factors are written in an optimistic manner, whereby if a usability risk factor is ranked closer to s*trongly agree*, it is more likely that it contributes to the occurrences of usability risk occurs during the software development process.

Only usability risk factors with point of *strongly agree* and *agree* is considered as factors contributing to usability risk and likely occurs during the software development process. The questionnaire is not accessible in this paper due to the space limitation.

Following the explanation given above, any inability to achieve characteristics defined in usability attributes a sub attributes leads to occurrence of usability risks and in this context we had defined a preliminary list of 40 potential usability risks in our previous study [28]. This list has been updated as shown in Table II.

TABLE I. USABILITY ATTRIBUTES AND SUB ATTRIBUTES

Usability	
Attributes	**Sub Attributes**
Effectiveness	Task Accomplishment, Operability, Universality, Flexibility, Error
Efficiency	User Effort, Finance, Resource Utilization, Performance
Comprehensibility	Clarity, Learnability, Memorability, Helpfulness
Satisfaction	Likeability, Comfort, Attractiveness, Trustfulness
Safety	User Safety, Third Party Safety and Environmental Safety

TABLE II. POTENTIAL USABILITY RISK DERIVED FROM USABILITY ATTRIBUTES

Potential Usability Risk	
Code	**Effectiveness (E)**
E1	Low percentage of task accomplishment
E2	Inappropriateness of the task output
E3	Incorrect task execution
E4	Incomplete functionalities to perform a task
E5	Low usage by persons with some disabilities
E6	Lack of cultural diversity in user interface
E7	Inability to adapt to changing user preferences and environment
E8	High ratio of failure resulted from human errors
E9	High ratio of failure resulted from execution errors
E10	Lack of user control
	Efficiency (F)
F1	Incorrect or inaccurate result produced
F2	Low estimation of cost in development
F3	Inadequate budget [project funding uncertainty]
F4	Low estimation of cost of human resources in development
F5	Lack of utilization of command
F6	Longer execution time of a task
F7	Maximum usage of memory while executing a task in software
	Satisfaction (S)
S1	Software not preferred or liked by the user
S2	Lack of software stability
S3	Lack of trust on software
S4	Unable to fulfil initial intention of user towards the software
S5	Bad response from user after using the software
S6	Confusing design (including the search facilities)
S7	Lack of aesthetic features and good UI design
	Comprehensibility (C)
C1	Lack of clarity in system's properties and functionalities
C2	Lack of skills for user and developer
C3	High complexity in design and architecture
C4	Inability to understand the software
C5	Inadequate training for user
C6	Longer time to learn the software
C7	Unable to remember elements and functionality of the software
C8	Incomplete and Inadequate documentation/ user manuals
C9	Lack of design documentation
C10	Insufficient support system (help)
	Safety (T)
T1	Loss of information/data
T2	High vulnerability to threat
T3	High prone to system failure/corruption
T4	Working environment prone to hazards
T5	Unable to avoid risk and damage to individuals other than the user when the system is in use
T6	Change in working environment

D. Data Collection

Since the respondents for these surveys are carefully chosen from the area of software development, non-probability samples are employed in this survey. Stratified sampling was reasonable to use in collecting data since 24 organization (23 ministries and MAMPU) were involved in this survey. The population of software developers and

software project managers in Malaysian Public Sector has been identified as 2514 people. Hence, the sample size of the respondents has been determined as 330 people using a software called G*Power.

Respondents were invited by email, which was forwarded to the Head of Information Technology Department in each organization. Of the 330, 270 (81%) respondents completed the survey and 19% of the respondents either did not provide any response or did not complete the survey. Each respondent was given choice to choose the mode of the questionnaire either thru online, soft copy or hard copy. From 270 completed surveys, 28.5% questionnaires are collected online, 66.7% was collected as hard copy and the rest collected thru email. To avoid bias, respondents were informed that data collection was fully anonymous and kept unknown to others.

IV. Result And Discussion

In this section, answer to our research question, *How to identify usability risks that occur during SDLC?* are discussed. The occurrences of usability risks are identified from respondents feedback on the usability risk factors listed in the survey. All usability risk factors that were either *agree* or *strongly agree* by respondent shows the occurrences of related usability risk.

A. Demography

Out of 270 respondents who have completely answered the questionnaire, 63% were female and 65% were between the age group of 30-40 years. In terms of experience in software development, most respondents (40.4%) have 1-5 years of experience and about 51.1% of total respondents have more than 5 years of experiences, which are sufficient to answer our questionnaire effectively. Almost 80.7% of the respondents have knowledge on usability practices which are an important aspect in our survey. This ensures that most respondents are able to understand and answer the questionnaire honestly.

B. Consistency of Constructs

To detect any inconsistency in the construction of the questionnaire, Cronbach's Alpha value was calculated. A factor is considered consistent when its risk factors yield a Cronbach's Alpha greater or equal to 0.7 [29]. Table III shows Cronbach's Alpha for our questionnaires.

The alpha coefficient for the 38 items is 0.905, suggesting that the items have relatively high internal consistency.

TABLE III. Cronbach's Alpha Value

Cronbach's Alpha	N of Items (number of questions in the questionnaire
0.905	38

C. Occurrences of Usability Risk Factors

Occurrence of usability risk factors in the survey reflect on the occurrences of usability risks itself. Occurrence of usability risk factors is determined by analyzing respondent's agreement (option '*agree*' and '*strongly agree'* in the survey).

It has been found that all usability risk factors listed in the questionnaire have more than 50% respondents agree that these usability risk factors contribute to occurrences of usability risk.

Eighteen factors are listed below and it is agreed by more than 90% of the respondents as contributing factor for usability risk:

- Ability of software to accomplish more tasks
- Appropriate way of showing task output (result)
- Ability of software to perform task correctly
- Providing complete functionalities to perform a task
- Stability in software
- Software's ability to produce correct and accurate result in return for user effort
- Software's ability in adapting to changing user preferences and working environment
- Software's ability to fulfill initial intention of users towards the software
- Good response from users after using the software
- Clear design (including search facilities)
- Aesthetic features and good user interface design in software
- Clarity in software's properties and functionalities
- The skill of users and developers in software development
- Providing adequate training for user leads
- The ability of user to learn to use the software easily and faster
- Complete and adequate documentation and user manual
- Sufficient support system in software such as "help"
- Safety of information or data

Hence, usability risk contributed from the above listed usability risk factors can be considered of having high occurrences during software development process and intense attention is needed in avoiding these risks.

Besides this, about 45 suggestions from respondents on usability risk factor were gathered from this survey. Suggested usability risk factors are analyzed and mapped with a preliminary list of potential usability risks in Table II. The purpose of this mapping is to eliminate redundant (explicitly and implicitly) usability risks and to identify new usability risk.

Six additional usability risk factors have been identified as:

i. *Detailed software penetration tests.*
ii. *Maintenance method.*

iii. *Updated software/ tools to develop a system.*
iv. *Developer's readiness to update the software from time to time to fulfill user needs.*
v. *Proper handling of request to update software to help on software maturity from time to time*
vi. *Changing version of software, can effected usability to user.*

From these six usability risk factors, two new potential usability risk (N) has been identified as

- N1 - Lack of detailed testing
- N2 - Lack of maintenance method

Lack of detailed testing such as usability testing and security testing is considered as usability risk because without proper and incomplete testing, usability features in a software product cannot be improved [30]. Detailed testing is also essential to ensure software, is secure and fulfills the initial requirement of the software.

Lack of maintenance methods [31] also contributes to usability risk. With good maintenance method, usability problems can be fixed with effective fixes such problems can be prevented from reoccurring in the future. Maintenance method includes updating activities in a software or system.

Some opinions such as *Lack of ownership from the user side* and *Poor study on user requirements* are not reckoned as usability risk factor because either it is not related, too generic and not specific, and ambiguous.

In summary, ICT practitioners have agreed and identified that all potential usability risk stated in Table II does occur during SDLC. Furthermore, two new usability risks have been defined and added to the initial list of potential usability list making total potential usability risk identified in this study is 42 risks. List of potential usability risk found in this study is as shown in Table IV.

TABLE IV. LIST OF POTENTIAL USABILITY RISKS

Potential Usability Risk	
Code	**Effectiveness**
E1	Low percentage of task accomplishment
E2	Inappropriateness of the task output
E3	Incorrect task execution
E4	Incomplete functionalities to perform a task
E5	Low usage by persons with some disabilities
E6	Lack of cultural diversity in user interface
E7	Inability to adapt to changing user preferences and environment
E8	High ratio of failure resulted from human errors
E9	High ratio of failure resulted from execution errors
E10	Lack of user control
	Efficiency
F1	Incorrect or inaccurate result produced
F2	Low estimation of cost in development
F3	Inadequate budget [project funding uncertainty]
F4	Low estimation of cost of human resources in development
F5	Lack of utilization of command
F6	Longer execution time of a task
F7	Maximum usage of memory while executing a task in software
	Satisfaction
S1	Software not preferred or liked by the user
S2	Lack of software stability
S3	Lack of trust on software
S4	Unable to fulfil initial intention of user towards the software
S5	Bad response from user after using the software
S6	Confusing design (including the search facilities)
S7	Lack of aesthetic features and good UI design
	Comprehensibility
C1	Lack of clarity in system's properties and functionalities
C2	Lack of skills for user and developer
C3	High complexity in design and architecture
C4	Inability to understand the software
C5	Inadequate training for user
C6	Longer time to learn the software
C7	Unable to remember elements and functionality of the software
C8	Incomplete and Inadequate documentation/ user manuals
C9	Lack of design documentation
C10	Insufficient support system (help)
	Safety
T1	Loss of information/data
T2	High vulnerability to threat
T3	High prone to system failure/corruption
T4	Working environment prone to hazards
T5	Unable to avoid risk and damage to individuals other than the user when the system is in use
T6	Change in working environment
	Others
N1	Lack of detailed testing
N2	Lack of maintenance method

V. THREAT TO VALIDITY

In this section, threat to validity of construct, internal and external for the literature search and survey were discussed.

A. Construct validity

To prevent construct validity problems in the survey, questionnaires were designed based on usability attributes and sub attributes defined in previously published quality model [25]. The questionnaire was pre tested with pilot test. Pilot test was carried out by distributing 30 questionnaires to software developers. Their feedback on content validity and readability was gathered. The questionnaire is then amended to ensure reliability and constructs validity in the questionnaire. Also, experts' opinions are considered in implementing the survey as the content validity.

B. Internal validity

Threats to internal validity are minimal in the survey because only descriptive statistical were used to identify potential usability risk. Demography data of respondents provide initial information to ensure the respondents are within the defined sample. There were about nine inquiries of respondents before and after completing the questionnaire, showing that most respondents understand questionnaire questions and answered the questionnaire truthfully.

C. External validity

Threats to external validity may reduce by the fact that the survey does not have very huge sample size and was only conducted in the Malaysian Public Sector.

VI. Conclusion

This paper presents a survey analysis that provides better understanding of potential usability risks, in the context of the Malaysian Public Sector. This survey, which is based on the use of Likert-scale questionnaires, is analyzed using descriptive analysis to determine the percentage of respondent that agrees on the occurrences of usability risk factors that could contribute to usability risk during software development process. Being so, the question proposed in the beginning of this paper; *How to identify usability risks that occur during SDLC?* are fully answered by the output of the survey.

In future, usability risk identified from this survey will be reconciled with usability risk found in the literature to ensure risks with the same meaning are considered only once. After the process of reconciliation, finalized list of usability risks is then used in development of questionnaire to collect information on usability risk's impact and likelihood on software development phases for future analysis. All of these aim at development of more usable and successful software product.

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