USABILITY EVALUATION FRAMEWORKS OF MOBILE APPLICATION:
A MINI-SYSTEMATIC LITERATURE REVIEW

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ABSTRACT

Usability Evaluation (UE) is defined as the process of measuring usability and recognizing explicit usability problems. UE in mobile application aims to identify the main issues in the user interface that may lead to human error, terminate the user interaction with the mobile application and cause user frustration. UE frameworks are considered as major success factor and led to higher acceptance for the mobile application since the usability testing is basic of software application development. Objective: The objective of this study is to conduct a systematic review on the published scientific literature to provide the usability attributes and guidelines reviewing the previous work. Method: The following selection criteria were used to perform a systematic search of the literature: research studies published in English language between 2012 and 2014, targeted frameworks are commercial including Android and IOS guidelines framework. The outcome of the study is Usability Evaluation Metrics frameworks. The following databases were searched: ACM and Google scholar. The included search terms were: Usability Evaluation, Usability metrics, Usability Framework, UE and Mobile Application. The criteria to select articles were limited to peer-reviewed scientific publications and review articles also included. Results: Based on the inclusion and exclusion criteria, screening was done to the 24 articles. 13 articles were found eligible to be included while 11 studies were excluded. The included studies consisted of 7 exploration tasks and visualization of interface (criteria-oriented), 6 goal-oriented approaches, and 1 non-moderated usability study. Discussion: in general, (7) of proposed usability evaluation metrics frameworks are focusing on interface visualization and graph representation, this reflected directly on developer and designer to cope within mobile application development process. On the other side, (6) studies focusing on developing conceptual usability framework. (1) Study investigates completely on automated usability framework. Conclusion: UE Framework of user interaction acts as a structured and general methodology for designing and evaluating mobile application by collecting usability information among user interaction with mobile applications. UE framework is consider a theory for describing, explaining, and predicting usability differences; (2) a method for defining, evaluating, and measuring usability objectively; (3) a process for designing built-in good usability.

Field of Research: Usability Evaluation, Usability metrics, Usability Framework, UE and Mobile Application.
1.0 Introduction

Usability is a quality attribute that assesses how easy to use the Graphical User Interface (GUI). The word "usability" also refers to methods for improving ease of use during the design process (Nielsen, 2012). Usability defined “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.” “Usability is an approach to product development that incorporates direct user feedback throughout the development cycle in order to reduce costs and create products and tools that meet user needs.” Guidance for Usability ISO 9241-11 (1998).

Usability evaluation (UE) set of methodologies for measuring and evaluation the usability aspects of a system user interface (UI) and identifying interface design problems. They are an important part of the overall user interface design process, which consists of iterative phases of designing, design prototyping, and design evaluating. (Dix et al., 1998, Nielsen, 1993). According to Preece (1994), evaluation is concerned with collecting data about the usability of a design or product by a specified group of end users for a particular activity within a specified environment or work context. There are different evaluation techniques commonly used by usability experts and professionals at the moment. These techniques are applied in different phases of the design of products. The findings and results of the usability evaluation can vary widely when different evaluators study the same graphical user interface, even if they use the same GUI evaluation technique (Jeffries et al., 1991; Molich et al., 1998, 1999; Nielsen, 1993). The usability evaluation usually takes subset of the possible actions users might take; as a result, it is recommended to use several different evaluation techniques (Dix et al., 1998; Nielsen, 1993) in parallel.

This paper aims to review previous studies and current measurement frameworks for usability evaluation through systematic literature review (SLR). The analysis of current model and previous study will result in a set of selected usability guidelines for mobile applications. The guidelines will be expended into measurement model consisting of metric for evaluation.

2.0 Related work

Paterno et al., (2007) proposed a methodology and environment that allows the remote evaluation of mobile applications. The system features a Mobile Event Logger that collects the information from the mobile device, and a tool called Multi-Device RemUsine that process, analyzes the user logged information and provides the necessary visualizations to analyze the usability of the application. Au et al., (2008) proposed another similar framework done to test usability of Mobile applications. Different aspects considered in usability testing of mobile device applications and introduced a list of functional requirements that automated usability testing tools should have in order to be effective were discussed. The Handheld User Interface Analysis (HUIA) testing framework was then developed that meets most of the requirements proposed.

In the field of web applications, usability analytics tools and visualizations are also important research areas. Waterson et al., (2012) developed a tool called Web-Quilt that collects information about users’ interaction with a web system and provides the necessary visualization that would allow web design teams to analyze the usability of the system. Graphs were used for the visualization. However, low-level data such as mouse movement and scrolling are not captured. Atterer et al. (2006) on the other hand presents the Usa-Proxy system that collects fine-grained user interaction data (e.g. mouse movements, keyboard input) aside from the basic usage data to allow detailed usability analysis of web pages. Tools such as the Usa-Proxy from Atterer et al., (2006) and Web-Quilt from Waterson et al.(2012) allows
gathering of web-based usability information without modifying the code from the web pages through a proxy-based logging system. Unfortunately, this technique cannot be applied to applications on mobile platforms unless there is an observing communication channel that observes action between the application and the user.

Coursaris & Kin (2005) in their study adapted a framework for the taxonomy of empirical mobile usability studies. Coursaris & Kin frameworks consist of four dimensions which are user, task, technology and environment. To select literatures studies for reviewing, three criteria were selected: a) a mobile technology was studied; b) the study was empirical in Nature; c) the time frame was from 2000 onward. 45 literatures were reviewed focusing the contextual factors studied, the core and peripheral usability dimensions measured and key findings. The paper found that efficiency, errors, effectiveness, attitude, satisfaction and Learnability are most commonly measured in empirical mobile usability studies.

The study of Adipat & Zhang (2005) proposed a comprehensive framework for Interface design for Mobile Application. Through literature review on Interface design for Mobile Applications, the study found out the challenges and recommendations to overcome these challenges. The major challenges in the interface design of mobile applications are generally caused by small screen size, inefficient data entry methods and low resolution. To overcome these challenges a theoretical frameworks was proposed which have four components: information presentation, user, mobile context, user, and data entry methods.. This study only considered two aspects of mobile usability (Information presentation and data entry), it may help both practitioners and HCI researchers to develop and design effective interface.

3.0 Research material and approach

This study consists of two phases in order to achieve the objectives mentioned earlier. The first phase will explore the previous study on usability measurement and later come out with the guidelines to evaluate mobile application. In the second phase, the metric for usability evaluation will be develop by referring to the guidelines developed in first phase. The electronic databases searched were ACM, IEEE, and Springer. A comprehensive strategy was used in order to include all possible articles that fit the criteria of this systematic review. Search terms included “Usability Evaluation“, “Usability metrics“, “Usability Framework“, “UE“ and “Mobile Application“. Studies were included if they were scientific articles published between 2012-2014 with full text provided, written in English language and followed appropriate arms of research evaluation, state of art practices, and qualitative review.

4.0 Results

In total, 24 published articles were identified and extracted through the included databases in this review after the removal of duplicates, these 24 articles were screened based on the inclusion and exclusion criteria, 13 articles were found eligible to be included while 11 articles were excluded. The included studies consisted of 7 studies visualization of interface (criteria-oriented), 6 goal-metrics approaches, and 1 non-moderated usability study, this lead to investigate to review the usability metrics approach in addition to non-moderated UE Metrics Framework. Table 1 also provides the results of all articles included in this systematic review.
4.1 Mobile application usability metrics

In this phase of results, the attributes for usability evaluation will be adopted by recent research in this field, People At Center of Mobile Application Development (PACMAD) originated by Harrison et.al (2013) by integrating the usability attributes developed by Nielsen (1998), the International Organization for Standardization (ISO) by (ISO/IEC, 1998). This phase will first review the PACMAD usability attributes prior to developing the metric to measure usability of mobile application. Figure 1 below describes the most popular usability evaluation attributes based on Nielsen, ISO and found in the recent integration of usability attributes in PACMAD model obtained from literature.

![PACMAD UE Framework](image)

The study of (Harrison, Flood, & Duce, 2013) introduced a new usability model named PACMAD (People at the Centre of Mobile Application Development) to overcome the limitations that exists in the present usability models used to measure the usability of mobile. 131 published researches on usability of mobile application were reviewed, from which the study found that most of the present usability models are generally based on three attributes: effectiveness, efficiency and satisfaction. The study also proposed a model adding another four attributes besides these three which are Learnability, Memorability, Errors and Cognitive Load. The introduced PACMAD model is based on the three factors named user, task and context of use which can overcome the limitations of present usability models. Table 1 also provides the results of all articles included in this systematic review.
Table 1: Included studies investigating UE frameworks dimensions, attributes and factors.

<table>
<thead>
<tr>
<th>Author(s)/year</th>
<th>Research approach</th>
<th>Research method</th>
<th>Research findings</th>
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<tbody>
<tr>
<td>Folstad et al., (2012)</td>
<td>Usability surveys to determines the common usability attribute (task completion, error rate and satisfaction)</td>
<td>Examines usability evaluation method, analysis and questionnaire survey.</td>
<td>They surveyed 155 usability practitioners on the analysis in their latest usability evaluation. They found that the most frequently used measures were, in decreasing order of importance: Satisfaction (80%); Task completion (84%); Error rate (45%); and Task time (33%). 112 respondents reported a usability test as their latest usability evaluation. 43 respondents reported a usability inspection as their latest usability evaluation.</td>
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<td>Shamsudeen et al., (2012)</td>
<td>Exploration of Usability dimension to identify evaluation characteristics of mobile applications</td>
<td>Review related studies as State of art for exploring usability characteristics of mobile applications.</td>
<td>The dimensions expected to be inherent in any mobile applications to determine its characteristics are functionality, reliability, flexibility, accessibility, portability, efficiency, maintainability, usability and responsiveness; iterated in line with the users’ requirements. Usability of the mobile applications stemming from the user centered design of the interface; the need for usable and intuitive interface is also an important quality requirement to be examined to ensure the quality assurance of the mobile</td>
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<tr>
<td>Lettner et al., (2012)</td>
<td>Automatic testing of mobile application with usability metrics by developing automated toolkit.</td>
<td>Categorizing usability metrics into Low level and Navigational Errors.</td>
<td>Provides analytical approach for low level usability metrics such as counts, ratios, hit rates and navigational error graphing</td>
</tr>
<tr>
<td>Raza et al., (2013)</td>
<td>Investigation study on Perspective of Usability and Functionality of Mobile Phones for Elderly</td>
<td>Mini-systematic review to cover usability perception for elderly people: performance, capabilities, facet of ageing, visual and visual acuity</td>
<td>Identifies Problems with current mobile phones such as too many and complex functions, little buttons, small displays, and difficult keypads.</td>
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<tr>
<td>Hussain et al., (2013)</td>
<td>Goal Question Metrics (GQM)</td>
<td>SLR of Usability Metrics framework for Mobile Phone Application.</td>
<td>Usability metrics for mobile phone application were developed and usability guidelines were issued as goal for GQM model (Accuracy, Time</td>
</tr>
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</table>
### Usability metrics development.

| Harrison et al., (2013) | Review of mobile usability evaluation models based on ISO and Nielsen. | Systematic Literature Review of mobile usability evaluation factor (user, context, task) | - It was found that almost 23% of the studies measured the cognitive load of the application under evaluation.  
- 2% of the studies evaluated Memorability.  
- Effectiveness, Satisfaction and Efficiency were included in over 50% of the studies. Errors were evaluated in over 30% of these studies.  
- **Context of use** and the **User** were considered in less than 10% of the papers. Context of use can vary enormously and so should be considered an important factor of usability. |

| Tapanee et al., (2013) | Adopting the ISO 9241 standard and Technology Acceptance Model (TAM) model to establish mobile application usability framework | The context of uses user, task, equipment, and environment. Three main usability measures (effectiveness, efficiency, and satisfaction) from ISO 9241 standard that apply for general usability measurement are applied | Gather related information and design a usability measurement framework that is specific for use with the mobile application. The outcome of the experiment is to investigate which variables in the context of use affected the mobile usability metrics and how application should be designed in order to increase usability. |

### 5.0 Discussion

This systematic review comprehended and presented 7 studies that explored Usability evaluation frameworks, their attributes and its association with usability factors. One possible limitation of this systematic review is the presence of possible bias based on the strategy of research. By reviewing research papers that met our research criteria and keywords which were mentioned in the paper abstract we have collects the following findings: There are no studies in determined period introduced comprehensive UE framework like PACMAD. We found that the most three research papers examined the usability attributes mentioned by Nielsen and ISO/IEC usability attributes together. Based on this systematic review, it does not seem there is definite agreement in the literature on the definition of some variables associated
Different studies examined the most used usability evaluation metrics without taking into account which usability attribute its being include. Most of reviewed study shown that studies examined and evaluated usability evaluation metrics not usability attributes. Shamsudeen et al., (2012) identified that the usability dimensions expected to be inherent in any mobile applications to determine its characteristics are usability, reliability, flexibility, portability, functionality, efficiency, maintainability, accessibility and responsiveness; iterated with the users’ requirements. Lettner et al., (2012), Hussain et al., (2013) provides analytical approach for UE metrics such as Accuracy, Features, Time taken, Safety, Simplicity, error rates hit counts and navigational graphing. Folstad et al., (2012) examined the most frequently used measures (task completion, error rate, satisfaction and task time).

Tapanee et al., (2013) adopt ISO-9241 and Technology Acceptance Model (TAM) to develop usability evaluation framework based only on main usability attributes (satisfaction, efficiency, and effectiveness) from ISO-9241 standard. Moreover, Harrison et al., (2013) found that the 23% of the reviewed studies measured the cognitive load of the application under evaluation. Context of use and the User were considered in less than 10% of the papers. 2% of the studies evaluated Memorability, but the Effectiveness, Satisfaction and Efficiency were studied in over 50% of the studies. Errors were evaluated in over 30% of these studies. Harrison introduced PACMAD framework as comprehensive UE framework, as mentioned before; he adopt ISO and Nielsen usability attributes, see figure 1.

6.0 Conclusion and Recommendations

The prominent framework of usability evaluation does not efficient to pick up the drawbacks of user interacting with mobile applications on a mobile platform. The extended use of mobile application is going rapidly, with the increasing of application development the usability occupying the crucial phase of mobile application development and mobile computing industry. For this reason, this paper aimed to review previous studies and current measurement frameworks for usability evaluation through systematic literature review (SLR). Future research must build up on the previous research and try to solve the mobile application usability problem related to small size, screen size, poor connectivity and other limitation.
References


