

Attribute Based Usability Metric Framework for Mobile Applications

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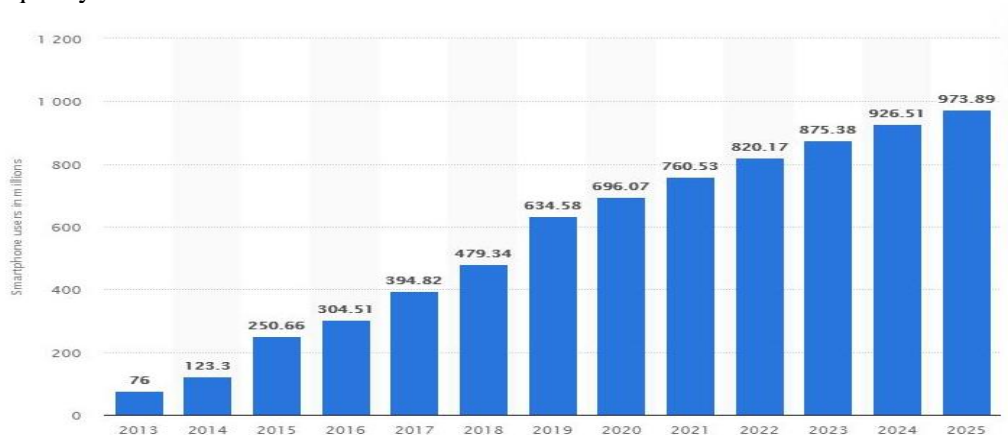
Abstract

The world becomes more technologically transformed and integrated society raises tremendous challenges for IT industry, especially for mobile computing. Mobile technology advancements have allowed the development of a vast variety of applications that can be used by people quick and easy. The usage of mobile applications in smartphones has increased significantly in recent years, enabling consumers to execute more activities in a mobile environment. necessitating greater focus on the usability of their technological products and, as a result, the rigorous implementation of Usability Engineering (UE) processes. Many researchers suggested that efficiency, effectiveness and user satisfaction are the attributes which defines the usability of mobile applications. But, in addition to these three, there are other attributes which affects the usability of mobile applications. We identified 29 attributes will affect the usability of mobile applications and by using these attributes, in this paper, we defined usability metric framework for mobile applications. We defined metrics for every usability attribute so that organizations can evaluate the usability of mobile applications by using this metrics. Around 144 usability metrics are defined in this work. All the usability evaluations are reported according to ISO 25066 standard. Usability Capability Maturity Level of the app defined according to ISO 15504 standard.

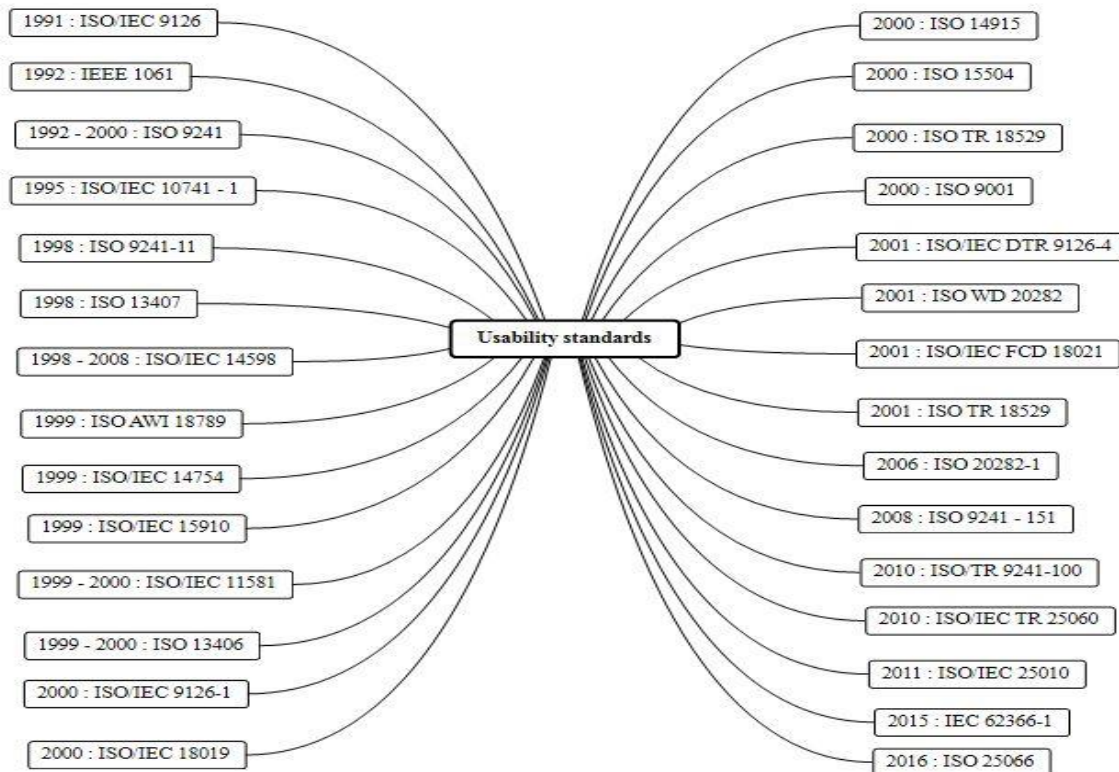
Keywords: Usability, attributes, usability score, usability metrics, CMM level, ISO 25066, ISO 15504.

1. INTRODUCTION

Smartphones are being more and more embedded into different facets of our everyday lives. Reports are saying 760.53 millions of people are using smartphones across the world [1]. The rapid development and intense competition for mobile apps establishes significant challenges for app organizations in terms of quality.



For example, if the app was not satisfied by the user, or if app was not effectively working, then user will not use that app. This user satisfaction and effectiveness are attributes of usability. Hence, usability is one of the main challenge for software developers while developing the app. ISO/IEC 9126 standard [2] defines usability is “*the capability of the software product to be understood, learned, and used as well as to be attractive to the user, when used under specified conditions*”. Another standard ISO 9241[3] defines usability means “*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*”. ISO defined more than 25 standards which shows the importance of usability in software products [4].



2. LITERATURE STUDY

From the year 1977 onwards, a lot of research is going on in the area of software usability. Many researchers did their experiments and evaluated the product by using different methods to define which attributes will affect the usability of a product. Most of the researchers accepted that efficiency, effectiveness and user satisfaction are major attributes which affect the usability of the product. Other than these three attributes, there are other attributes which will affect the usability of the app. In 1977, McCall et al. defined usability attributes are Operability, training and communicativeness [5]. Boehm, in 1978, defined usability attributes are Portability, maintainability [6]. According to GOULD, usability attributes are System performance, system functions, user interface. They defined these attributes in 1988 [7]. In 1989, Booth defined usability attributes are Usefulness, effectiveness, learnability, attitude [8]. Shackel, in 1991, defined usability attributes are Effectiveness, learnability, flexibility, subjectively pleasing [9]. In 1991, Bevan et al. defined Type of product, type of user, ease of use, acceptability are usability attributes. [10] According to Schneiderman et al., in 1992, Rate of errors by users, subjective satisfaction, speed of performance, retention over time, time to learn are identified as usability attributes [11]. In 1992, FURPS defined usability attributes are Aesthetics, human factors, user documentation, consistency, wizards and agents, training materials, online and context sensitive help [12]. In 1993, Hix et al. defined usability attributes are Learnability, long-term user satisfaction, advanced feature usage, first impression, performance, retainability. [13]. Lowgren defined Relevance, efficiency, learnability, attitude are usability attributes. [14]. Nielsen defined Learnability, efficiency, memorability, errors, satisfaction are usability attributes. [15]. Preece et al. defined usability attributes are Safety,

effectiveness, efficiency, enjoyableness [16]. In 1994, Preece et al. identified Learnability, efficiency, throughput, flexibility, attitude are also affected the usability [17]. In 1995, Lewis defined System usefulness, information quality, interface quality are usability attributes [18]. In MUSiC model, user performance measures like task effectiveness, temporal Efficiency, length or proportion of productive period are important usability attributes [19]. In 1998, Dix et al. defined Learnability, flexibility, robustness are usability attributes [20]. In 1999, Constantine et al. defined usability attributes are Efficiency in use, learnability, rememberability, reliability in use, user satisfaction [21]. Arms defined Data and metadata, interface design, functional design, computer systems and networks are usability attributes [22]. In 2000, Frokjaer et al. defined usability attributes are Components, effectiveness, efficiency, satisfaction [23]. In 2001, Battleson et al. defined the usability attributes are Remember, use, errors for its target users, specific tasks, easy to learn [24]. Donyaee et al. defined usability attributes are Efficiency, effectiveness, productivity, satisfaction, learnability, safety, trustfulness, accessibility, universality, usefulness [25]. Seffah et al. defined QUIM model and in that, they defined usability attributes are Efficiency, effectiveness, productivity, satisfaction, learnability, safety, trustfulness, accessibility, universality, usefulness [26]. In 2002, Blandford et al. defined usability attributes are Technical, cognitive, social, design-oriented [27]. Brinck et al. defined Efficient to use, learn, remember, error tolerant, subjectively pleasing, functionally correct are usability attributes [28]. In 2003, Efficiency, effectiveness, satisfaction, learnability, security are the usability attributes defined by Abran et al. [29]. Bass et al. defined Efficiency, effectiveness, satisfaction, learnability, security are usability attributes [30]. In 2009, knowability, operability, efficiency, robustness, safety, subjective satisfaction are usability attributes defined by Alonso-Rios et al. [31]. In 2010, Tamir et al. defined usability attributes are Learnability, operability, understandability [32]. In 2013, Harrison et al. defined PACMAD model and according to this, usability attributes are Effectiveness, efficiency, satisfaction, learnability, memorability, errors, cognitive load, user, task, context [33]. These are few works and their views with respect to usability of mobile applications.

Based on literature, in this paper, we considered the top most 29 usability attributes and defined metrics for each metric to evaluate the usability of mobile apps. Around 144 metrics are defined to evaluate the usability of the mobile app. Each metric can be measured and get the usability metric score by using suitable usability evaluation method. After measuring all metric scores, normalize all the values and report the results defined by ISO 25066 standard [34]. Finally, to define Capability Maturity Level(CMM) of the mobile app, we followed ISO 15504 standard [35].

3. PROPOSED WORK

To evaluate usability of a mobile app, we proposed 7-step usability metric framework which evaluates the usability by calculating each attribute’s usability score. From the existing studies, we selected 29 attributes which are important and defined metrics for each attribute represented in table 1 and detailed flowchart for usability metric framework shown in figure 4.

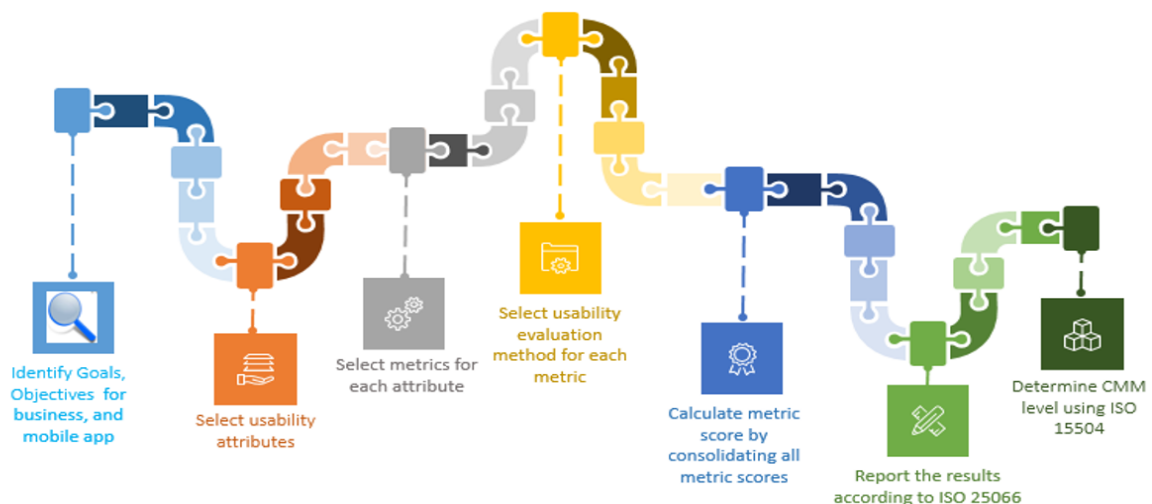


Figure 3: Usability metric framework for mobile applications

The proposed usability metric framework contains 7 steps showed in figure 3.

1. Identify goals, objectives for business, and mobile app
2. Select the usability attributes based on goals and objectives
3. Select metrics for each selected attribute.
4. For evaluating each metric, select suitable usability evaluation method.
5. Calculate the usability score of the mobile app by calculating the metric score of each attribute.
6. Report the results according to ISO 25066 standard.
7. Determine the CMM level of the app according to ISO 15504 standard.

ISO/IEC 25066 - 2016

ISO/IEC 25066 – 2016 [34] provides the Common Industry Format for evaluating the usability of mobile applications. Earlier version, ISO/IEC 25062 gives the formative report of usability testing. But, in ISO 25066, it covers usability evaluations in different perspective rather than subjective or formative purpose. This standard provides the evaluation report that contains covers 64 content elements. By the end of the evaluation, we can

- identifying the positive usability findings
- identifying the usability defects and problems
- eliciting user requirements
- measure the level of usability
- assess the conformance criteria
- identifying the strengths and weakness of the product
- fill the gap between users and stakeholders
- identifying whether the product, service or system is accessible

The evaluation report, contains 64 content elements, organized into sections. They are

1. Executive summary
(includes name and description of object of evaluation, summary about remaining sections)
2. Description of object of evaluation
(defines what entity actually to be evaluated)
3. Purpose of evaluation
(defines the reasons for conducting the evaluation)
4. Context of evaluation (Method)
 - General
 - Evaluators/Participants
 - Tasks
 - Evaluation environment
5. Procedure
 - Design of the evaluation
 - Data to be collected
6. Results
 - Data analysis
 - Presentation of results
7. Interpretation of results and recommendations

ISO 15504

ISO 15504 also known as Software Process Improvement and Capability Determination (SPICE) [35] is “a set of technical standards documents for the computer software development process and related business management functions”. To determine the capability of a process (i.e., usability), ISO 15504 defined a 6 layered scale (level 0 to level 5; lower capability to higher capability).

Level 0: Incomplete

Level 1: Performed

Level 2: Managed

Level 3: Established

Level 4: Predictable

Level 5: Optimizing

S.No	Attribute	Definition	Usability metrics
1	Accuracy	The degree to which the result of a measurement, calculation, or specification conforms to the correct value or a standard.	<ul style="list-style-type: none"> Loss of accuracy on user location tasks
2	Accessibility	The quality of being able to be reached or entered	<ul style="list-style-type: none"> Web Accessibility Barrier Score Page Measure Web/Screen Interaction Environments Inaccessible element rate Accessibility issue rate Widget coverage measure Overall coverage measure
3	Adaptability	The quality of being able to adjust to new conditions	<ul style="list-style-type: none"> Use of user profile
4	Attitude	A settled way of thinking or feeling about something	<ul style="list-style-type: none"> Likert scale
5	Attractiveness	A settled way of thinking or feeling about something	<ul style="list-style-type: none"> Implicit association test
6	Auditory	relating to the sense of hearing	<ul style="list-style-type: none"> Displays per output Displays per task Screen dimension Hearing Aid Speech Perception Index Hearing Aid Speech Quality Index
7	Co-existence	The state or fact of living or existing at the same time or in the same place	<ul style="list-style-type: none"> Co-existence with phone activities
8	Cognitive load	refers to the used amount of working memory resources	<ul style="list-style-type: none"> Fixations, gaze points and heat maps Text summarization Predefined statements with Likert-scale ratings
9	Consistency	The quality or condition of being consistent	<ul style="list-style-type: none"> Retention rate Churn rate Daily Active Users Monthly Active Users Geographical Location Stickiness Customer Acquisition Cost Return on Investment Number of registered users User growth rate Number of crashes Number of upgrades Customer life time App activation rate Brand awareness
10	Design aesthetics	Aesthetics is a core design principle that defines a design's pleasing qualities	<ul style="list-style-type: none"> UUP score Balance Density Complexity Alignment
11	Ease of use	Describes how easily users can use a product	<ul style="list-style-type: none"> Predefined statements with Likert-scale ratings
12	Effectiveness	The capability of producing a desired result or the ability to produce desired output. When something is deemed effective, it means it has an intended or expected outcome, or produces a deep, vivid impression	<ul style="list-style-type: none"> Completion rate Number of errors Number of steps required to complete a task Number of taps related to an app usage Number of taps unrelated to an app usage Number of times that a back button was used Ease of use - displays per output Ease of use - displays per task
13	Efficiency	A measurable concept, quantitatively determined by the ratio of useful output to total useful input.	<ul style="list-style-type: none"> Time based efficiency Overall relative efficiency Duration spent on each screen Duration to complete task User's error rate Response time to get information from server Response time to get information from cache Size of application in mobile device Size of help in mobile device Device memory cleanup after transaction Network throughput
14	Error rate	Number of errors occurs in unit time	<ul style="list-style-type: none"> Amount and type of errors occurred Application ability to recover from errors
15	Fault tolerance	A system's ability to continue operating uninterrupted despite the failure of one or more of its components	<ul style="list-style-type: none"> Use of cache
16	Instability	The action of installing someone or something, or the state of being installed	<ul style="list-style-type: none"> Installations success Ease of installation Cost per install Total number of installations Total number of uninstalls

S.No	Attribute	Definition	Usability metrics
17	Interaction	reflecting the real user experience after one interaction with the user interface	<ul style="list-style-type: none"> • Daily Active Users • Monthly Active Users • Screen flow • Active users • Average Daily Sessions per Daily active users • Touch Heatmaps • Screens with the most interactions • Screens with the shortest and longest viewing times • The number of screens per session • Net promoter score • App click-through rate • Session length • Session depth • App open rate • Session interval
18	Interoperability	The ability of computer systems or software to exchange and make use of information	<ul style="list-style-type: none"> • Use of user profile • Use of middleware • Use of standard protocols
19	Learnability	Quality of products and interfaces that allows users to quickly become familiar with them and able to make good use of all their features and capabilities	<ul style="list-style-type: none"> • Number of attempts to solve a task for first time • Number of assists during performing a task in first time • Number of errors performed by a user in first time repeating similar pairs of tasks in each session duration to reach a pre-specified proficiency
20	Memorability	The quality of being worth remembering.	<ul style="list-style-type: none"> • Effects of response time • Duration of pauses • Predefined statements with Likert-scale ratings
21	Navigation	The skill or process of plotting a route and directing	<ul style="list-style-type: none"> • Screen flow • Abandonment rate • Screen dimension • Geo metrics
22	Operability	The ability to keep a piece of equipment, a system or a whole industrial installation in a safe and reliable functioning condition	<ul style="list-style-type: none"> • Measure the degree of control on cancel support, undo support, explicit user action, error prevention • Screen size • Display self-adjustment possibilities
23	Performance	The action or process of performing a task or function	<ul style="list-style-type: none"> • Message completion • Crash Rate • API Latency • App Load per period • Network Errors • Total app response time • Bounce rate • Load time • Devices • Carriers • App speed FINANCIAL • Life time value • Average revenue per user • Time to first purchase • Cost per acquisition • Customer life time value • Effective customer acquisition cost • Effective cost per mile • Paid conversion rate • Return on Investment
24	Recoverability	To regain a normal or usual condition	<ul style="list-style-type: none"> • Resume of transaction after disconnections

25	Satisfaction	The act of fulfilling a need, desire, or appetite, or the feeling gained from such fulfillment.	<ul style="list-style-type: none"> • Task level satisfaction • Test level satisfaction • customer satisfaction score • Golden score • App store rankings/ratings • User reviews • In-App feedback • Support response time
26	Security	the state of being free from danger or threat.	<ul style="list-style-type: none"> • Secure messages and information on device • Message time on air • CVSS Score

S.No	Attribute	Definition	Usability metrics
27	Simplicity	The quality or condition of being easy to understand or do.	<ul style="list-style-type: none"> • How many clicks does it take to complete a step? • How many times do you switch context? • Friction Index • Number of menu levels • Number of performed gestures to reach a destination object • Duration of searching a button to perform a specific function
28	Suitability	The quality of being right or appropriate for a particular person, purpose, or situation	<ul style="list-style-type: none"> • Predefined statements with Likert-scale ratings • Tasks based on user location • Update of user location based tasks • Speed of user location update
29	Understandability	Capable of being understood	<ul style="list-style-type: none"> • Display load • Clarity of operation possibilities • Operation menu existence • Completeness of operation menu

Table 1: Usability metrics with respect to attributes

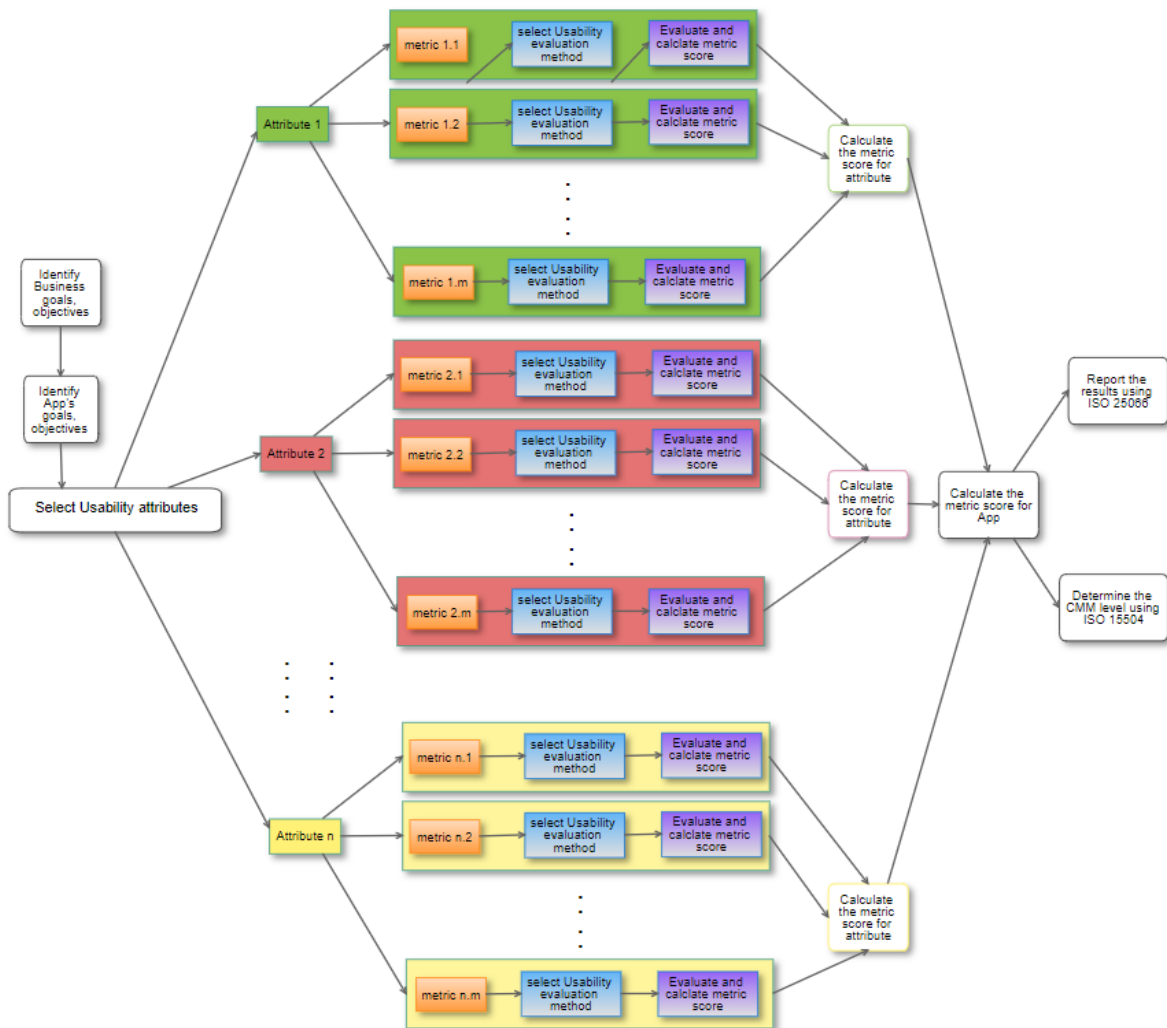


Figure 4: Flowchart for usability metric framework

CONCLUSION

In this work, the authors defined around 144 usability metrics for 29 usability attributes. To evaluate the usability of mobile applications, based on the goals and objectives of organization, they can select the usability attributes. And then identify the usability metrics for each selected attribute. To evaluate those metrics, select the usability evaluation method and calculate the metric score. Like that, calculate all metric scores, from that, calculate the usability attribute score and then calculate the usability score of the mobile application. After defining the usability score, report the results according to ISO 25066 Common Industry Format and by using ISO15504, the authors defined the CMM level of the app.

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