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Towards Building a General Guideline Approach to Facilitate the Process of Measuring Software Usability.

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Highlights

- **The paper proposes a unified framework to measure usability through four key dimensions—Effectiveness, Efficiency, Learnability, and Satisfaction—using specific mathematical formulas and standardized questionnaires.**
- **It addresses the common neglect of usability in software development by providing a structured, organized approach that transforms abstract quality metrics into practical, actionable data for developers.**
- **Validation through a case study on the "Al Wahda Mobile" service demonstrates the framework's simplicity and its potential for universal application across mobile, web, and desktop environments.**

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ABSTRACT

Usability and the extent of customers' satisfaction with the applications that accomplish their work are important factors in facilitating their work procedures. For this reason, many criteria have been revealed that deal with the mechanism of usability. In addition to the attempts of many researchers to provide ways and methods to address and measure this feature, this was, in a way, generic or abstract, which causes many developers to neglect usability and not address it primarily in the development stage.

In this paper, we present a unified framework that addresses the elements of usability in a detailed and organized manner, supported by a clear measurement method that includes a number of mathematical equations and guiding questions that facilitate this process for developers. A case study was presented as an applied example of the proposed framework, as it was clear from the target audience how simple it is to utilize this framework. Therefore, this framework can be considered as a supportive point to encourage developers to focus on usability more.

1. Introduction

Software quality is an utmost issue of software products. Software quality is the most important aspect for successful software as well as customers' need of all. Growing customers' expectation from software systems, organizations encouraged to fulfil users' satisfaction by fulfilling their expectations. Users will be satisfied if the software follows the demanded functionality with the desired quality level. The quality is a measure of user satisfaction in terms of achieving the non-functional and functional requirements of the system (Tan *et al.*, 2013)

The last few years have seen unprecedented growth in the development, design and deployment of software. With the unprecedented growth in distributed applications, especially for the Internet, developers, technical staff and training instructors no longer have direct access to the end-user of their software systems. Software usability is now considered an essential aspect of productivity and plays a crucial role in the acceptance of software. Nonetheless, without a detailed understanding of the software systems' end-users, enhancing the usability and learnability of these systems presents a significant quality challenge in their design (Alain *et al.*, 2003).

As a fundamental and significant concept in interaction design, usability serves as an overarching measure of how effectively users can interact with a computer, ensuring that interaction is successfully achieved. It is also a quality metric from the user's perspective, assessing whether a product is effective, easy to learn, safe, efficient, memorable, error-free, and enjoyable to use. It is essential to take into account users' expectations and experiences, as these should elicit both delightful and surprising reactions. (Alain *et al.*, 2003) Usability is a critical quality requirement when viewing both products and processes. It can be applied in numerous settings, focusing on execution time, performance, user satisfaction, learnability, etc. The contribution of this article is to suggest a general framework for conducting usability testing through previous studies and discuss the research questions, methodologies, and usability attributes. Next, it suggests a general framework that standardizes usability attributes and provides detailed instructions on how to perform usability testing (Tan *et al.*, 2013).

2. Literature review

In the next section, we cite literature regarding usability and synopsize some of the most relevant findings. First, ISO 9241-11 (1997) standard (Paz & Pow-Sang, 2016), defined 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". However, ISO/IEC 9126- 1 (2001) states that usability is "the capability of the software product to be understood, learned, used and attractive to the user, when used under specified conditions (Budanov, 1997).

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There are different quality models and standards like ISO 9126 (1991), ISO 25000 (2005), McCall (1977) and Boehm (1978), quality model which identify different quality attributes of software products. ISO 9126 categories of software product quality consist of six attributes: Functionality, Reliability, Usability, Efficiency, Maintainability and Portability. Each of them is further subdivided into sub-attributes (ISO/IEC 9126, 1991). There are several internal and external qualities that use metrics provided to measure the quality attributes of the system.

McCall defines usability as "the effort required to learn, operate, prepare the input and interpret the output of a program" (Grady, 1992). However, the fact that it was already included as a quality factor did not really imply attention from software engineers, but it was regarded as an extension of general data processing system design. This perspective was typical of its time.

Shackel in 1991 framed usability in terms of system effectiveness, easiness to learn, flexibility and user attitude. The notion is split into four attributes: effectiveness in terms of performance (e.g., time, errors, number of sequence activities) in learning, relearning and carrying out a representative range of operations, learnability within a specified time from the installation and start of user training" and "the amount of training and user support". Flexibility allows "adaptation to some specified percentage variation in tasks and/or environments beyond those first specified" and attitude "within acceptable levels of human cost in terms of tiredness, discomfort, frustration and personal effort" (Leavitt, 2006).

Nielsen (1993) connects usability to five key characteristics: ease of learning, effectiveness, recall, error rate, and overall satisfaction. Each definition begins with phrases like "the system must be or possess," which specifically refers to its ability to be simple to learn, efficient in operation, easy to retain in memory, devoid of mistakes, and enjoyable to engage with.

Jia Tan (2009) created a name framework (FOUUX) that associates usability with nine attributes: efficiency, effectiveness, satisfaction, productivity, learnability, safety, accessibility, generalizability, and understandability. There are also sub-attributes represented in: Time behavior, Resource utilization, Attractiveness, Operability, Likeability, Flexibility, Minimal action, Minimal memory load, Memorability, Accuracy, User Guidance, Consistency, Self-descriptiveness, Feedback, Completeness, Fault tolerance, Readability, Controllability, Navigability, Simplicity, Privacy, Security, Quality of outcome, Experts' Users' attitudes and perceptions (TAN, September 2009).

In 2015, a conceptual model for the measurement of mobile learning (m-Learning) application usability characteristics was proposed. A prototype smartphone application to estimate m-Learning application usability problems has also been designed and utilized. The model was tested with regard to ease of use, satisfaction, attractiveness, and learnability (Hasan & Al-Sarayreh, 2015).

Lina and Khalid (2015) proposed a model that divides usability into 12 main attributes: effectiveness, efficiency, satisfaction, productivity, universality, learnability, appropriateness, recognizability, accessibility, operability, user interface aesthetics, and user error protection (Lina and Khalid 2015).

Organization for Standardization (ISO) 9241-11 2018 defined usability as" the extent to which a system, product or service can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use" (9241-11, 2018). I believe that usability is not limited only to effectiveness, efficiency, and satisfaction. Other attributes must be taken into consideration.

Paweł Weichbroth (2018) Stated Software usability plays a major role in the quality perceived by its users. However, a variety of definitions and associated attributes show that there is still no consensus in this area. The overall purpose of this paper is to revisit usability attributes. Also preparing a time-framed knowledge map to present the results of a critical and rigorous literature review, the aim of which is to demonstrate all the relevant usability definitions and related attributes introduced until now.

Despite the proposed efforts, such a process is still considered the hardest challenge that faces the development team, due to the absence of an existing comprehensive model that covers all the fuzzy usability attributes. Its main contribution, however, is an approach constituted in covering several fuzzy usability attributes; modelling them in a homogeneous manner; and providing different measures for evaluating these attributes during every stage of the system development. Consequently, this work aims to introduce a mechanism that simplifies the usability testing process.

3. The proposed approach

A review of standards, literature, and models related to usability shows that there is a need for a cohesive framework for defining and measuring usability. Currently, no link between usability attributes defined in various standards or models. The variation in definitions and terminology makes it difficult to apply usability standards in practice. A consolidated framework can offer a consistent terminology for usability attributes. It will integrate various perspectives on usability and its assessment in a cohesive and standardized manner. This framework can act as a reference for analyzing and understanding the data gathered on the usability of products. By providing a unified terminology for usability, it will enhance comprehension. This may assist developers or testers who might not yet be acquainted with usability metrics in formulating a solid usability measurement strategy for various types of applications.

3.1. Usability measurement

This paper includes introducing a guideline approach that contributes to measuring the usability of the software. It provides a mechanism for measuring usability attribute in order to facilitate the process of interaction between the user and the software, which focuses on user inputs and outputs. The stages of the proposed framework will be applied, which are measuring Effectiveness, Efficiency, learnability, and satisfaction, and linked to the questionnaire questions (Appendix A) that were used to measure the usability application, and this questionnaire will be represented by the question code and number. This is according to the following Fig. (1).

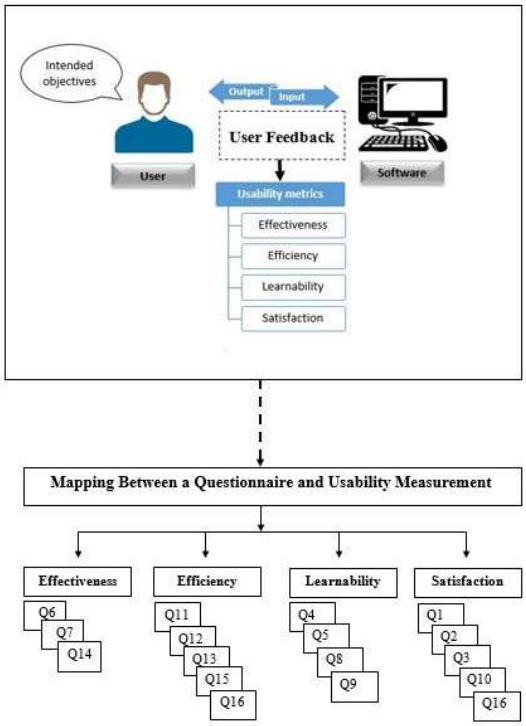

Fig. 1. A conceptual overview of the proposed usability guideline approach.

– DEFINITION OF AL WAHDA MOBILE SERVICE

Al Wahda Mobile is a service provided by Al Wahda Bank in Libya, whereby the bank's customer is able to see everything that happens in his bank account after subscribing to the service. This application provides many services.
This application provides many services that include:

Task 1: Request to prepare check book.

Task 2: Account statement request sent to the e-mail (e-mail).

Task 3: Request to purchase recharge cards (Al Madar Al Jadeed, Libyana, Internet, landline).

Task 4: Transfer from account to account.

Task 5: Know your current balance.

Task 6: Account statement with the last three transactions.

Task 7: The last three opponent moves.

Task 8: The last three movements add.

Task 9: Currency selling rates.

Task 10: Currency buying rates

Task 11: Change the password to a new number.

Task 12: Search for new application updates.

3.1.1 Usability metric for effectiveness

"The capability of the software product is to enable users to achieve specified tasks with accuracy and completeness in a specified context of use" (ISO/IEC 9126- 4, 2004). Effectiveness is about the high degree of accuracy with which users can complete their goals. The product has to be able to support the user while performing tasks. Effectiveness can be measured using the completion rate of tasks and the number of mistakes that users make when trying to finish a task (Alturki & Gay, 2017).

– Completion Rate

Effectiveness can be determined by analysing completion rates, which are a key usability metric. The completion rate is calculated by assigning a binary score of '1' when a participant successfully finishes a task and '0' when they do not. Its straightforward nature makes the completion rate an easy-to-understand metric, contributing to its popularity. Additionally, this metric can be gathered at any point during the development process. Therefore, effectiveness can be expressed as a percentage using this formula (Eq. 1):

$$\text{Effectiveness}=\frac{Number\ of\ tasks\ completed\ successfully}{Total\ nummber\ of\ tasks\ undertaken}\times 100\% \qquad (1)$$

While it's ideal to strive for a task completion rate of 100%, research conducted by Jeff Sauro reveals that the average Task Completion rate is 78%, based on an evaluation of 1,100 tasks. This study also noted that the completion rate greatly varies depending on the specific context of the task being assessed (Alturki & Gay, 2017).

The effectiveness will be applied to the questionnaire questions of this category, which are Q6, Q7, and Q14.

Q6**:** Is the information you get from the application accurate and clear?
Task 1: Request to prepare check book.
Task 2: Account statement request sent to the e-mail (e-mail).
Task 4: Transfer from account to account.

As for the accuracy and clarity of the information, the information was not clear to the users, as 65% of the users saw the inaccuracy and clarity of the information as shown in Fig. 2.

Table 1. Explains the effectiveness results for question No 6.

Users NO	Task 1	Task 2	Task 4	Effective-ness
1	1	1	0	66.6 %
2	0	1	1	66.6 %
3	1	1	1	100 %
4	0	0	1	33.3 %
5	1	1	0	66.6 %
6	0	0	0	0%
7	1	1	1	100 %
8	0	0	1	33.3 %
9	1	1	0	66.6 %
10	1	1	1	100 %
11	0	0	1	33.3 %
12	1	1	0	66.6 %
13	1	0	1	66.6 %
14	0	0	0	0%
15	0	1	1	66.6 %
16	1	1	0	66.6 %
17	1	1	0	66.6 %
18	0	1	1	66.6 %
19	0	0	1	33.3 %
20	0	0	0	0%
21	0	0	1	33.3 %
22	1	1	1	100 %
23	1	0	1	66.6 %
24	0	1	1	66.6 %
25	1	1	1	100 %
26	0	1	1	66.6 %
27	1	0	1	66.6 %
28	0	1	1	66.6 %
29	1	1	1	100 %
30	1	0	1	66.6 %

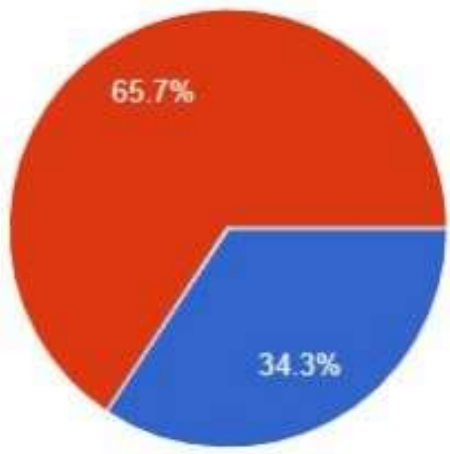

Fig. 2. Accuracy and clarity: Yess: ; No:

3.1.2 Usability metric for efficiency

"The capability of the software product to provide appropriate performance, relative to the number of resources used, under stated conditions." (ISO/IEC 9126- 1, 2001). Efficiency serves as a metric for assessing the duration required to accomplish a task. Typically, it refers to the time participants spend completing a task.

Efficiency can be determined through two approaches: Overall Relative Efficiency and Time-Based Efficiency (Alturki & Gay, 2017).

A. OVERALL RELATIVE EFFICIENCY

The overall relative efficiency is determined using the following Eq. (2)

$$\text{Overall Relative Efficiency} = \frac{\sum_{i=1}^{R}\sum_{i=1}^{n} n_{ij}\, t_{ij}}{\sum_{i=1}^{R}\sum_{i=1}^{n} t_{ij}} \times 100\% \quad (2)$$

B. TIME-BASED EFFICIENCY

The efficiency based on time is determined using the Eq. (3)

$$\text{Time-Based Efficiency} = \frac{\sum_{i=1}^{R}\sum_{i=1}^{n} \frac{n_{ij}}{t_{ij}}}{N \times R} \quad (3)$$

R: the total count of users

N: the total count of tasks

nij: outcome for task (i) by user (j). If the task is completed successfully, then nij = 1; otherwise, nij = 0.

tij: duration taken by user "j" to finish task "i". If the user is unable to complete the task successfully, the time recorded will be until the user decides to give up on the task.

Here, the Efficiency will be applied to the questionnaire questions of this category, which are Q11, Q12, Q13, Q15 and Q16.
Q12: The website responds quickly as you move between pages?

Task 3: Open the account detection, then open the detection of Prepaid cards
N = 1
R = 30

Table 2. Explains the Efficiency results for question No 12.

User NO	Nij	Tij
1	1	5
2	1	3
3	1	3
4	0	4
5	0	6
6	1	5
7	1	3
8	1	3
9	0	4
10	0	6
11	0	5
12	0	6
13	0	6
14	0	6
15	1	1
16	1	5
17	0	1
18	1	6
19	0	4
20	1	4
21	0	3
22	1	4
23	1	2
24	0	6
25	1	4
26	0	5
27	0	6
28	0	1
29	1	4
30	0	6

Efficiency = {(1*5) + (1*3) + (1*3) + (0*4) + (0*6) + (1*5) + (1*3) + (1*3) + (0*4) + (0*6) + (0*5) + (0*6) + (0*6) + (0*6) +(1*1) + (1*5) + (0*1) + (1*6) + (0*4) + (1*4) + (0*3) + (1*4) + (1*2) + (0*6) + (1*4) + (0*5) + (0*6) + (0*1) + (1*4)+(0*6)/ (5+3+3+4+6+5+3+3+4+6+5+6+6+6+1+5+1+6+4+4+3+4+2+6+4+ 5+6+1+1+4+6)} * 100

Efficiency = { 52 / 127 } * 100= 40.9%

Most of the answers about the speed of moving between pages on the website were that the speed of moving between pages is slow to medium.

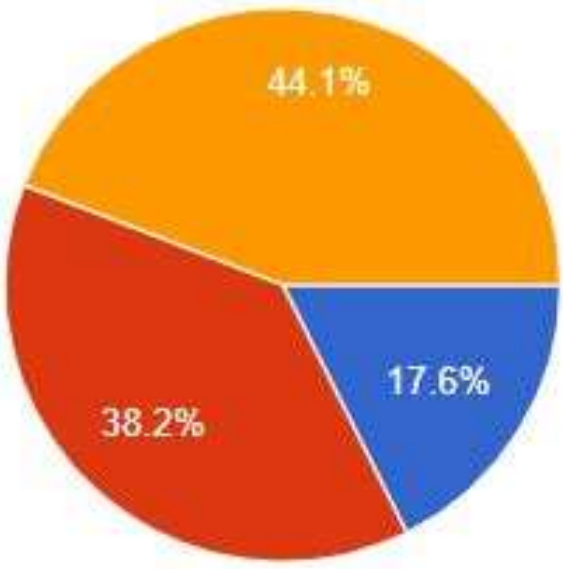

Fig. 3. The speed of response to the navigation between the pages of the website : Quick Response, : Average Response, : Slow Response

3.1.3 Usability metric for learnability

The software's ability allows the user to understand how to use it effectively. (ISO/IEC 9126-1, 2001)

Steps for a metric for learnability

Step 1: Determine the Metric
Step 2: Determine the Number of Trials
Step 3: Gather and Plot the Data
Step 4: Analyze the curve

Here, the Learnability will be applied to the questionnaire questions of this category, which are: Q4, Q5, Q8, and Q9.
Q8: Does the app's user interface contain enough helpful instructions to run the app when you use it for the first time?
Task 11: Change the password to a new number.

Fig. 4. Change the password to a new number.

In the final part of the survey, users were asked questions to measure the usability of the application. More than 75% users responded that the user interface did not contain enough instructions to help them enough to run the application when they first used it.

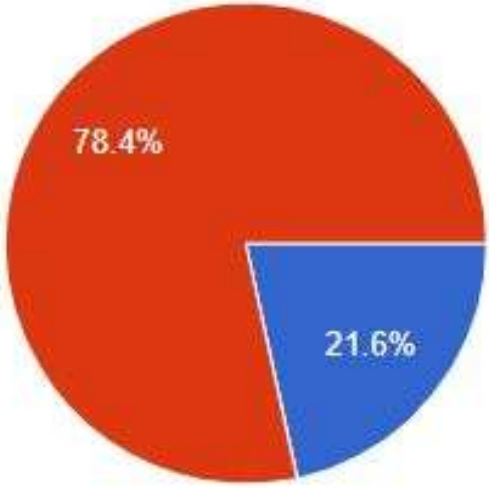

Fig. 5. User manual showing how to use: Yes: , No:

3.1.4 Usability metric for satisfaction

"Satisfaction measures assess the user's attitudes towards the use of the product in a specified context of use." (ISO/IEC 9126- 4, 2004). Here the satisfaction will be applied to the questionnaire questions of this category, which are**:** Q1, Q2, Q3, Q10, Q16. This evaluation was to measure the extent of users' satisfaction with the usability of the application. The evaluation points were from (1) to (5), with (1) indicating the lowest level and (5) indicating the highest level. evaluation score. There was a discrepancy in the evaluation scores, where (30%) of the users gave the weakest evaluation of the application. The following figure shows the evaluation results.

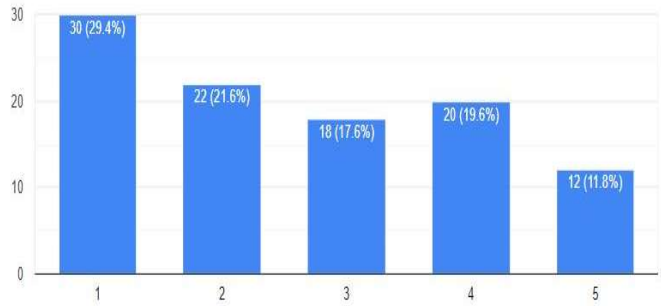

Fig. 6. Net recommendation points

4. Limitation

The current research focused on validating the framework through a case study of the "Al Wahda Mobile" service in Libya. This represents a positive constraint, as it proved the effectiveness of the methodology in the banking sector, paving the way for testing the framework's universality by applying it to other software types.

5. Conclusion

The process of ensuring software quality increases the life of its use. Therefore, we presented a unified framework that deals with the process of measuring usability. It deals with effectiveness, efficiency, learnability, and satisfaction stages, and is entirely focused on measuring the usability of the targeted programming. As a support, indicative questions have been developed in the form of a general questionnaire to facilitate the process of measuring each item of usability. The framework was applied to a commonly used case study in order to ensure the effectiveness of the proposed framework in the measurement process.

This framework shows a general work that can be applied to many different applications. We recommend it as a future solution to this work in order to improve, according to any comments that may be received, in order to ensure that its usability contributes to encouraging developers to use it. Finally, the proposed framework can be applied to most software application types such as Windows applications, app mobile and web applications.

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