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Research paper

A Systematic Mapping Review of Software Usability Metrics

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Abstract

The importance of usability in software applications is growing day by day, because it is increasingly the competitiveness of organizations to always offer better tools that meet the needs of their customers and users. However, there is no single instrument to measure the usability of software. There are several techniques to evaluate software usability, these evaluations being quantitative and qualitative. The main way to quantitatively evaluate a software product is by using software usability metrics. The present study performs a systematic mapping review to determine if there are experiences that use software usability metrics.

Keywords: *Human-computer interaction; software usability; systematic mapping review; usability metrics; user-centered design.*

1. Introduction

Due to the high competitiveness of the companies, they saw the need to offer better products, causing users to feel more comfortable and satisfied. The factors that allow software to achieve this quality are usability and user experience [1].
Nowadays on the web, usability is a necessary condition for survival. If a website is difficult to use, people will stop using it. If the page does not clearly state what a company offers and what users can do on the site, people will stop using it. If users get lost on a website, they will stop using it. If the information on a website is difficult to read or does not answer the key questions of users, they will stop using it [2].
Currently, there are several studies that address usability from different approaches and times of application. For example, guidelines for obtaining requirements have been prepared in [3], and defined architecture patterns that include usability functionalities [4], [5].
For its part, the International Organization for Standardization (ISO) has defined usability metrics within some standards it has published, such as: ISO / IEC 9126, ISO / IEC 9241, ISO / IEC 25010 among others.
This research aims to identify the metrics that have been used to evaluate the usability attribute, so that they can be considered in the design process of the platforms and in their maintenance. Especially, it is expected to know how used are the software usability metrics defined by organizations and specialized institutions, and how widespread is its application in the literature.
This systematic mapping review seeks to find evidence of the use and application of metrics to evaluate software products in the different areas of industry.

2. Background

2.1. Usability

Usability is defined as the ease of an object to be used. In the case of software and web platforms usability is what concerns whether users can achieve the specified objectives with effectiveness, efficiency and satisfaction when using the software or web platform [6].
In addition, usability is the most important attribute that determines the ability of individuals to interact easily with a web platform and to help establish if it is successful [7].

2.2. Metrics

The definition of a metric or an indicator is established as a relation between the quantitative and / or qualitative variables that allow observing the situation and the trends of change generated in the observed process [8].
According to [9], metric is a scale of measurement and the method used for measurement. It also defines some properties that the metrics must meet in order for their results to be considered valid: reliable, repeatable, reproducible, available, exact, meaningful, and indicative.

3. Conducting the Systematic Mapping Review

3.1. Research Questions

The main objective of this work was to determine how frequently software usability metrics are used and in what contexts they are used. Additionally, we identified whether published metrics are already used (for example, ISO, UTUM, SUMI, etc.) or if the researchers themselves defined their own metrics.
RQ1: What are the most widely used software usability metrics?

RQ2: In what contexts are software usability metrics being applied?
In order to execute this revision, general concepts based on PICOC are defined. As this work will not compare interventions, the "comparison" criterion was not considered. The concepts are detailed in Table 1.

Table 1: Definition of the General Concepts Using PICOC

Criterion	Description
Population	Software products
Intervention	Usability metrics
Outcomes	Cases studies where usability metrics are used to evaluate software products
Context	Software industry, academic context, and all kinds of empirical studies

3.2. Search Strategy

The following search string is defined to validate if there is evidence of the use of software usability metrics:
("software project*" OR "software product*" OR "software process*" OR "software application*" OR "software testing*" OR "software validation*" OR "software verification*") AND ("usability" OR "usable") AND ("ISO/IEC" OR "ISO*" OR "international organization for standardization")
The following exclusion criteria apply:

1. Items that are not peer-reviewed.
2. Conference articles that have not been published in a journal.
3. Books will not be considered.
4. Items that do not use ISO metrics, use adaptations, or improper use.
5. Proposals without validation.
6. Use of outdated rules.
7. Items that cannot be accessed.

3.3. Search Process

The search is done in the databases: Scopus, IEEE Library, and ISI (considering Web of Science & Web of Knowledge).

3.4. Selection of Primary Studies

The studies retrieved from the search were examined by the authors to determine whether or not they are included in the present work. The evaluation process includes a review of the entire document: title, abstract, introduction, background, study case, results and conclusions. In order for the study to be considered within this work, it must meet the inclusion criteria: it must report the definition of usability metrics applied to a software product.
On the other hand, the exclusion criteria that have been considered are: that the studies are not applied to a software product and that the study is not available for study.

3.5. Data Extraction

After obtaining all the studies, a template with the following information is elaborated:

1. Paper ID
2. Paper title
3. Author(s)
4. Type of publication
5. Year of publication
6. Extraction date
7. Database in which the study was found

The search for studies was conducted in April 2017. 493 studies were obtained from the three databases. After applying the inclusion and exclusion criteria, 69 studies were selected for the review process. Table 2 shows the summary of search results.

Table 2: Summary of Search Results

Database Name	Search Results	Duplicated Papers	Relevant Papers
SCOPUS	148	-	19
ISI	332	55	47
IEE	13	10	-
TOTAL	**493**	**65**	**66**

4. Data analysis and Results

In order to determine which the most used software usability metrics are, the metrics defined by organizations or by the authors of the same studies have been identified. In Table 3 you can see the results.

Table 3: Frequency of Use of the Software Usability Metrics

Usability Software Metrics	Number of times the metrics were used	Percentage (%)
Metrics are not defined	24	36.36%
Metrics defined by authors	21	31.82%
ISO/IEC 9126	7	10.61%
UTUM	3	4.55%
SUMI	2	3.03%
VALUTA	2	3.03%
UMUX	2	3.03%
ISO 25010	1	1.52%
ISO 9241	1	1.52%
MOSCA	1	1.52%
Quality in Use Integrated Measurement (QUIM)	1	1.52%
UGAM	1	1.52%
Total	**66**	**100.00%**

From the reviewed works, more than third part of them of them refer to the importance of metrics, suggest their use but do not define their own metrics or advice the use of some in particular. In almost 32% of the work done, the authors define at least one software usability metric to evaluate a software product in a particular context. Between these two categories are almost 69% of the papers reviewed. Only the remaining 31% of the papers reviewed use the metrics established by organizations or those that were published at the time of the search.

4.1. Software Usability Metrics

4.1.1. ISO/IEC 9126

It was published by the International Organization for Standardization (ISO) and the International Electrotechnical Commission (IEC), which defines a software product quality model, quality characteristics, and related metrics. This can be applied on any software product [9].

4.1.2. UTUM

The UIQ Technology Usability Metrics (UTUM) is a usability test package for mass market mobile devices. UTUM enables quality assurance by measuring usability empirically on the basis of metrics for satisfaction, efficiency and effectiveness, complemented by the test leader's observations [10].

4.1.3. SUMI

The Software Usability Measurement Inventory (SUMI) is a solution to the recurring problem of measuring users' perception of the usability of software. It provides a valid and reliable method for the comparison of competing products and differing versions of the same product [11].

4.1.4. VALUTA

The Automatic Tool for the Usability Verification at Abstraction Level is a tool that supports the generation of the formal specification of existing interactive visual applications in an automatic

manner, so to perform the related usability controls. Checking the usability of interactive applications at a formal level, allows a designer to perform feedback analysis of the environment under consideration [12].

4.1.5. UMUX

The Usability Metric for User Experience (UMUX) is a four-item Likert scale used for the subjective assessment of an application's perceived usability. It is designed to provide results similar to those obtained with the 10-item System Usability Scale, and is organized around the ISO 9241–11 definition of usability [13].

4.1.6. ISO/IEC 25010

This standard is the successor of ISO/IEC 9126 and describe software quality in use in general. It is composed of eight characteristics, which are subdivided into sub-characteristics that can be measured internally or externally [14].

4.1.7. ISO/IEC 9241

Defines usability as the: "The extent to which a product can be used by specific users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use". The key attributes highlighted by this definition are elaborated by the standard ISO/IEC 9241 as follows: Effectiveness, Efficiency, Satisfaction, and Context of use [15].

4.1.8. MOSCA

The Software Quality Systemic Model is intended to specify software system quality. MOSCA integrates three quality models: product, and development process while considering the human perspective. This model relies on total systemic quality concepts. MOSCA consists of four levels, as follows: Dimensions, Categories, Features, and Metrics [16].

4.1.9. QUIM

Quality in Use Integrated Measurement (QUIM) is a consolidated model for usability measurement. Similar to the existing software engineering models and most usability measurement frameworks described earlier, QUIM is hierarchical in that it decomposes usability into factors, then into criteria, and finally into specific metrics [17].

4.1.10. UGAM

Usability Goals Achievement Metric was proposed to measure user experience goals and IOI (Index of Integration) to measure extent of integration of Human Computer Integration activities in Software Engineering processes [18].

4.2. Results by Software Domain

Below are the main domains of software applications that were found in the primary results. The results are shown in Table 4.
Most of the systems evaluated were those of the educational field, especially ELearning systems. One of the reason that there are many evaluations of Educational websites could be that its effective and attractive web presence is increasing as online technology is becoming an important part of the educational process [19]. The other large group of systems evaluated were web sites or web applications. The third large group is formed by the systems of general use. Among these three types of systems are almost 41% of the systems evaluated.
The other software domains have few applications of usability metrics. Which suggests that the use and application of usability metrics is not well disseminated in the literature.

Table 4: Frequency of Main Software Domain Involved in the Studies

Software Domain	Number of software applications that were evaluated	Percentage (%)
Education	11	16.67%
Web sites / Web applications	9	13.64%
General Purpose Systems	7	10.61%
Software development tools	4	6.06%
Component based software	3	4.55%
No information about the software	3	4.55%
Mobile applications	3	4.55%
Applications for elderly	2	3.03%
Biological domain	2	3.03%
Graphics	2	3.03%
Library Systems	2	3.03%
Word processor	2	3.03%
Industrial environment	2	3.03%
3D software	1	1.52%
Adaptive systems	1	1.52%
Aeronautic	1	1.52%
Embedded systems	1	1.52%
Military environment	1	1.52%
E-commerce	1	1.52%
Open Source systems	1	1.52%
Parallel computing	1	1.52%
Health	1	1.52%
Real time system	1	1.52%
Process modelling system	1	1.52%
Project estimation system	1	1.52%
Software Language Engineering tool	1	1.52%
Distributed Computing	1	1.52%
TOTAL	**66**	**100.00%**

Table 5 shows the metrics obtained in the revision and applied to certain software domains. From the results shown, it is observed that most of the authors who defined their own metrics sought to evaluate software from the educational field.
In the same way, of the reviewed works that do not define metrics or recommend any, in the majority of the cases they elaborated their works under the domain of educational software.

Table 5: Main Software Usability Metrics by Software Domain

Usability Software Metrics	Number of times the metrics were used	Number of times the metric was used	Percentage (%)
Metrics are not defined	Graphics	2	8.33%
	Biological domain	2	8.33%
	Real time system	1	4.17%
	3D software	1	4.17%
	Web sites / Web applications	2	8.33%
	Education	5	20.83%
	Distributed computing	1	4.17%
	Adaptive systems	1	4.17%
	Industrial environment	1	4.17%
	Project estimation system	1	4.17%
	Applications for elderly	1	4.17%
	General purpose Systems	2	8.33%
	Component based software	1	4.17%
	Software development tools	1	4.17%
	Library systems	1	4.17%
	Software language engineering tool	1	4.17%

Metrics are not defined	Mobile applications	2	9.52%
	Library Systems	1	4.76%
	Education	4	19.05%
	General Purpose Systems	2	9.52%
	No information about the software	1	4.76%
	Component based software	2	9.52%
	Parallel computing	1	4.76%
	ECommerce	1	4.76%
	Embedded systems	1	4.76%
	Health	1	4.76%
	Aeronautic	1	4.76%
	Web sites / Web applications	1	4.76%
	Software development tools	1	4.76%
	Word processor	2	9.52%
ISO/IEC 9126	Web sites / Web applications	2	28.57%
	Mobile applications	1	14.29%
	Military	1	14.29%
	Education	1	14.29%
	No information about the software	1	14.29%
	Applications for elderly	1	14.29%
UTUM	Industrial environment	1	33.33%
	General Purpose Systems	1	33.33%
	Software development tools	1	33.33%
SUMI	Education	1	50.00%
	No information about the software	1	50.00%
VALUTA	Web sites / Web applications	1	100.00%
UMUX	Web sites / Web applications	1	50.00%
	General Purpose Systems	1	50.00%
ISO/IEC 25010	General Purpose Systems	1	100.00%
ISO/IEC 9241	Process modeling system	1	100.00%
MOSCA	Open source systems	1	100.00%
QUIM	Web sites / Web applications	1	100.00%
UGAM	Software development tools	1	100.00%

Figure 1 shows the main usability metrics by software domain in a summarized way. It emphasizes that in the Educational field, greater effort has been made to apply and/or define software usability metrics. It is also observed that the application of usability metrics in the different software domains is still low.

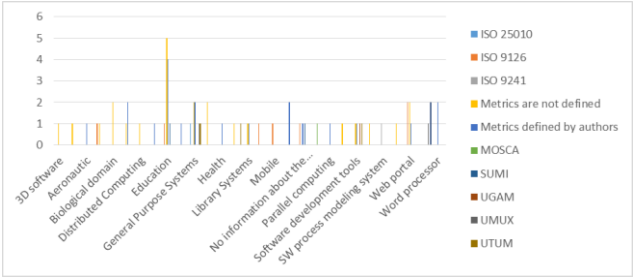

Fig. 1: Main software usability metrics by software domain.

5. Conclusion

One of the main objectives of this work was to identify the main software usability metrics that are applied in the different software domains. Especially, we sought to know which metrics defined by specialized institutions or organizations were the most used.

The authors did not expect to find that the metrics defined by institutions or organizations were applied in a small amount. In some of the reviewed papers it was even found that their authors indicated that the metrics defined by institutions were not being applied in the amount that was expected.

The authors of this paper have analyzed the work obtained and agree with other authors that the metrics defined by institutions are rigid and cannot be adapted to the software products that are to be evaluated. For this reason, this paper shows that in the third part of the studies found, the authors have preferred to define their own evaluation metrics before using those already established in the literature or those defined by institutions.

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