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Usability of Interfaces

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1. Introduction

In recent years human society evolved from the "industrial society age" and transitioned into the "knowledge society age". This means that knowledge media support migrated from "pen and paper" to computer-based Information Systems.

This evolution introduced some technological, organizational, and methodological changes affecting the demand, workload and stress over the workers, many times in a negative way. Due to this fact Ergonomics assumed an increasing importance, as a science/technology that deals with the problem of adapting the work to the man, namely in terms of usability.

Usability is a quality or characteristic of a product that denotes how easy this product is to learn and to use (Dillon, 2001); but it is also an ergonomic approach, and a group of principles and techniques aimed at designing usable and accessible products, based on user-centred design.

User-centred design is a structured development methodology that focuses on the needs and characteristics of users, and should be applied from the beginning of the development process in order to make software applications more useful and easy to use (Averboukh, 2001; Nunes, 2006).

Formally, usability is defined 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" (ISO 9241 - Part 11) (ISO 9241, 1998). Therefore usability is a relative concept, which is dependent on several factors. It applies equally both to hardware and software design.

Adequate usability is important because it is a characteristic of product quality that leads to improving product acceptability, increasing user satisfaction, improving product reliability and it is also financially beneficial to companies. Such benefit can be seen from two points of view, one related with workers' productivity (less training time and faster task completion), and the other with product sells (products are easier to sell and market themselves, when users had positive experiences) (Nunes, 2006).

A product designed with the user psychological and physiological characteristics in mind, is more efficient to use (less time to accomplish a particular task), easier to learn (operations can be learned by observing the object), and more satisfying to use (Nielsen, 1993).

Usability covers a broad spectrum of aspects regarding a product. Goud (Gould, 1995) argues that, despite several of these aspects are least discussed in literature, usability of components include components as System performance, System functions, User interface, Reading materials, Language translation, Outreach program, Ability for costumers to modify and extend, Installation, Field maintenance and serviceability, Advertising or Support-group users. However, some authors see this broad spectrum of issues as a step beyond usability, which is designated as User Experience Design. This theme is addressed in another chapter of the present book. The present chapter addresses usability in a traditional way, the one that relates mainly with the usability of interfaces, including aspects of system performance and system functions.

Literature describes a number of methodologies and tools that contribute to ensure the usability of a product considering, namely, the phase of development in which they are applied, the amount of resources they require and how they are applied (e.g., synthesized in (Usability Partners, 2011)). Most of these tools or methods are dedicated to a specific phase of project development (design phase, preliminary design and prototyping phase, and test and evaluation phase), some are applied in two different phases, and very few are appropriate to be applied in the three phases. In this chapter we will discuss with some detail the test and evaluation phase considering different methods, such as, analytic and heuristic evaluations, and SUMI.

A quite new challenge in terms of usability is the context of use of applications that exploit new forms of interfacing with the product, such as the use of touch and multitouch interfaces. The body of knowledge available is still limited, nevertheless, there is a vast literature on guidelines and good practices for generic usability, which can also be adapted to the context of touch and multitouch interfaces (e.g., (Microsoft, 2009), (MSDN, 2011), (HHS, 2006), (Largillier et al., 2010), (Meador et al., 2010), (Kreitzberg & Little, 2009), (Capra, 2006)).

The present chapter presents an overview of the general principles to observe when a user-centred design is adopted, provides a summary of methods and tools that are available to support the design and evaluation of products with good usability, offers examples of guidelines and good practices that can be adopted.

2. Usability and interfaces – Basic principles and heuristics

In some countries usability is a legal obligation. For instance, in European Union according to the Council Directive, 90/270/EEC, of 29 May, on the minimum safety and health requirements for work with display screen equipment, when designing, selecting, commissioning and modifying software the employer shall take into account the following principles:

- The software must be suitable for the task;
- The software must be easy to use and adaptable to the operator's level of knowledge or experience;
- Systems should provide users with information on its operation;
- Systems must display information in a format and at a pace adapted to users;

- The principles of software ergonomics must be applied, in particular to human data processing.

Therefore to meet these requirements the software development should be accompanied by an evaluation of its usability.

In simple terms, the usability of a system can be seen as the ease with which the system is used by its users, i.e., with the characteristic of being easy to use, or as is often said, to be "user friendly".

Therefore, usability is a feature of interaction between the user and the system. Usability evaluation can be based on a set of attributes, such as, operator performance (completing a task with reduced turnaround times and low error rates), satisfaction or ease of learning.

Usability can also be seen as synonymous of product quality, namely of software quality.

Usability is a critical aspect to consider in the development cycle of applications which requires a user-centred design and carrying out usability testing. Such tests cannot ignore the context of use of the software, which is essential to conduct usability studies.

When human-machine interfaces are built taking into account usability criteria, interfaces are capable of allowing an intuitive, efficient, memorable, effective and enjoyable interaction. As Nielsen refers these characteristics influence systems' acceptability by users (Nielsen, 1993). Figure 1 schematically represents the relationship of these particular characteristics with others that influence system usability.

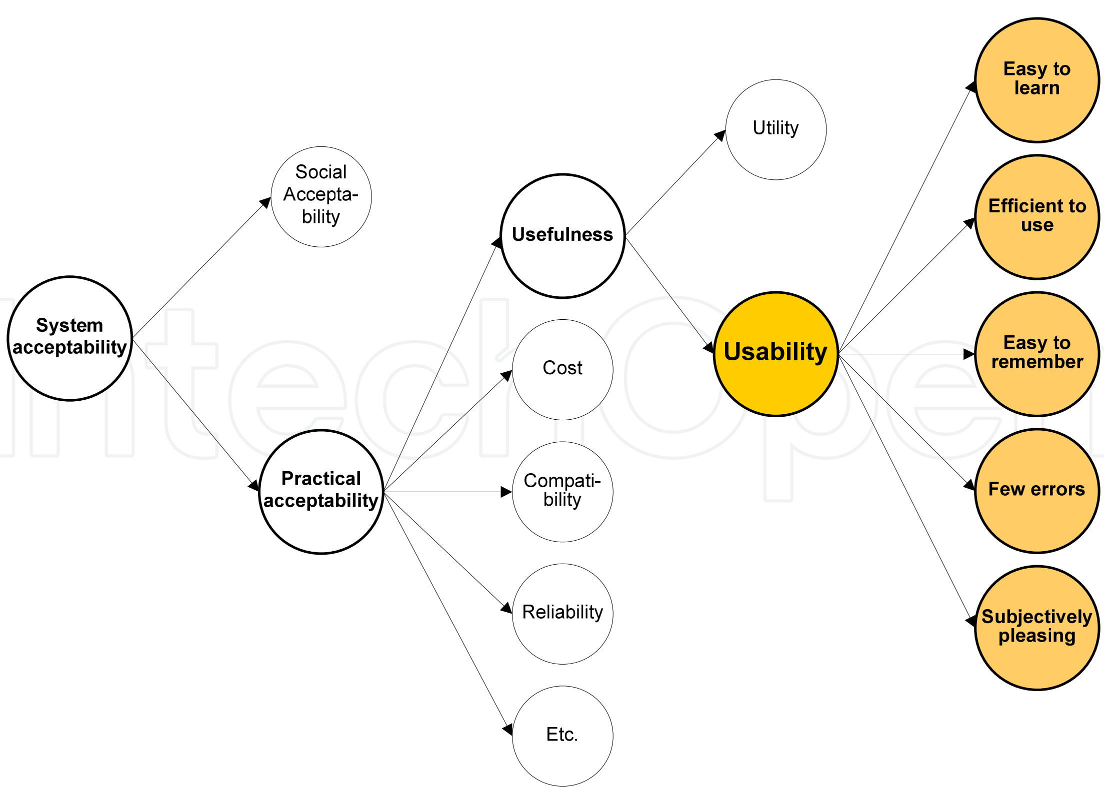

Fig. 1. A Model of the Attributes of System Acceptability (Nielsen, 1993).

Therefore, because of their influence in the usability of a system, it is important to define the concepts inherent to this set of characteristics (Nielsen, 1993):

- Ease to learn - the system must be intuitive, i.e. easy to use, allowing even an inexperienced user to be able to work with it satisfactorily;
- Efficiency of use - the system must have an efficient performance, allowing high productivity, i.e., the resources spent to achieve the goals with accuracy and completeness should be minimal;
- Memorability - the use of the system must be easy to remember, even after a period of interregnum;
- Errors frequency - the accuracy and completeness with which users achieve specific objectives. It is a measure of usage, i.e. how well a user can perform his task (e.g. set of actions, physical or cognitive skills necessary to achieve an objective);
- Satisfaction - the attitude of the user towards the system (i.e., desirably a positive attitude and lack of discomfort). Ultimately measures the degree to which each user enjoys interacting with the system.

According to Jordan (1998), when designing a product to achieve an appropriate usability developers should adopted the following 10 principles:

1. Consistency - similar tasks are performed in the same way;
2. Compatibility - the method of operation is compatible with the expectations of users, based on their knowledge of other types of products and the "outside world";
3. Consideration of user resources - the operation method takes into account the demands imposed to the resources of users during the interaction;
4. Feedback - actions taken by the user are recognized and a meaningful indication of the results of such activities is given;
5. Error Prevention and Recovery - designing a product so that the user likely to err is minimized and that, if errors occur, there may be a quick and easy recovery;
6. User Control - user control over the actions performed by the product and the state in which the product is are maximized;
7. Visual Clarity - the information displayed can be read quickly and easily without causing confusion;
8. Prioritization of Functionality and Information - the most important functionality and information are easily accessible by users;
9. Appropriate Transfer of Technology - appropriate use of technology developed elsewhere in order to improve the usability of the product;
10. Explicitness - offer tips on product functionality and operation method.

The design has also to consider the finite capability of humans to process information, to take decisions, and to act accordingly. These human characteristics have been thoroughly studied in the last decades, considering the Human Computer Interaction. Researchers that became a reference are, for instance, Hick (1952), Fitts (1954), or Miller (1956).

William Hick was a pioneer of experimental psychology and ergonomics. One of his most notorious researches was focused on the time a person takes to make a decision as a result of the possible alternatives, considering the cognitive information capacity, which was expressed as formula known as the Hick's Law (Hick, 1952).

Paul Fitts was a psychologist and a pioneer in human factors, which developed a mathematical model of human motion, known as Fitt's Law, based on rapid aimed movements (Fitts, 1954). This model is used, in the realm of ergonomics and human-computer interaction, to predict the time required to rapidly move to a target area, for instance to point with a hand or a finger, or with a pointing device in a computer interface.

George Miller was a cognitive psychologist that studied the average capacity of the human working memory to hold information. His studies concluded the number of objects an average person can hold is 7 ± 2 (Miller, 1956). This is known as the Miller's Law or the "magical number 7". One relevant consequence of this finding relates with the ability of humans to evaluate and judge alternatives, which is limited to 4 to 8 alternatives.

Accommodating all these research contributions in a set simple of design principles is problematic; therefore a different approach is the definition of heuristics for the assessment of the interfaces usability. An example of such approach is the work of (Gerhardt-Powals, 1996) that developed a set of heuristics to improve performance in the use of computers, which includes the following rules:

- Automate unwanted load:
  - Free cognitive resources for high-level tasks;
  - Eliminate mental calculations, estimations, comparisons, and unnecessary thinking.
- Reduce uncertainty:
  - Display data in a clear and obvious format.
- Condense the data:
  - Reduce the cognitive load, low-level aggregated data turning them into high-level information.
- Present new information with meaningful ways to support their interpretation:
  - Use a familiar framework, making it easier to absorb;
  - Use day-to-day terms, metaphors, etc..
- Use names that are conceptually related to functions:
  - Context-dependent;
  - Trying to improve recall and recognition;
  - Grouping data consistently significantly reduces the search time.
- Limit data-oriented tasks:
  - Reduce time spent in acquiring raw data.
  - Make the appropriate use of colour and graphics.
- Include only information on the screens that the user needs at any given time.
- Provide multiple coding of data, where appropriate.
- Practice a judicious redundancy.

A software program developed taking into account usability principles offers advantages, as decreased time to perform a task; reduced number of errors; reduced learning time, and improved satisfaction of system's users.

3. Reference standards on Usability

The international standard reference on the Usability is ISO 9241 - Part 11 from the International Organization for Standardization (ISO 9241, 1998). ISO 9241-11 emphasizes the usability of computers is dependent on the context of use, i.e., that the level of usability achieved depends on the specific circumstances in which the product is used. The context of use includes users, tasks, equipment (hardware, software and materials) and the physical and social environment, since all these factors can influence the usability of a product within a working system. Measures of performance and user satisfaction are used to evaluate the work system as a whole, and when the focus of interest is a product, these measures provide information about the usability of the product in the particular context of use provided by the work system. The performance and user satisfaction can also be used to measure the effect of changes in other components of the work system. Figure 3 shows schematically the set of factors to consider in evaluating the usability of a system, within the framework of ISO 9241-11.

ISO/IEC FDIS 9126-1 (ISO/IEC9126-1, 2000) follows the same general line. This standard for software quality that suggests a model based on quality attributes, divided into six main features, and the usability of them. According to this standard, usability is "the capability of the software product to be understood, learned, used and attractive to the user, when used under specified conditions".

This definition reinforces the idea that a product has no intrinsic usability, only a capability to be used under specified conditions (in a particular context). Usability depends on who are the users, what are their goals and where the users perform their tasks. Therefore, to analyze the usability of a software product, it is necessary to identify who are the users and what are its characteristics; what are the needs of users and what are their tasks; and what is the environmental context (social, organizational and physical).

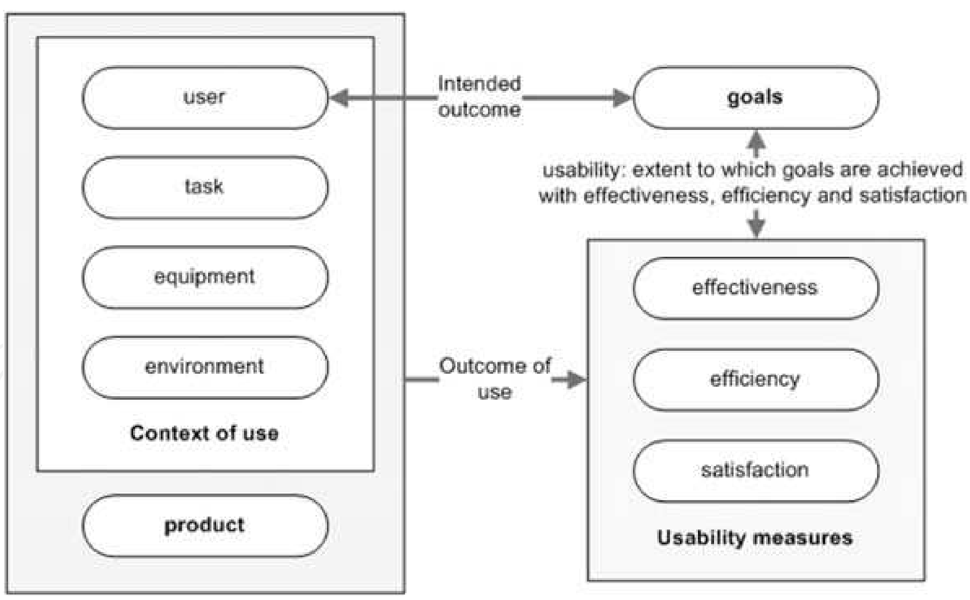

Fig. 2. Usability framework, according to ISO 9241-11 (ISO 9241, 1998).

Generally, the usability is evaluated based on the following dimensions (ISO 9241, 1998):

- Effectiveness (i.e., accuracy and completeness with which users achieve specified goals) as measured by success/failure that presents a user in the use of a product (e.g.,% of tasks completed, error rate or ratio hits /failures);

- Efficiency (i.e., resources expended in relation to the accuracy and completeness with which users achieve goals) as, for example, the time to complete the task, workload (physical and mental), deviations from the critical path or error rate;
- Satisfaction (i.e., freedom from discomfort and positive attitudes while using the product), as based on subjective judgments, e.g. ease of use (absolute or relative), usefulness of features, or like/dislike the product.

4. User-centred design

One approach to the use of the concept of software usability is the user-centred design. The user-centred design is a structured development methodology that focuses on the needs and characteristics of users, should be applied from the beginning of the development process in order to produce applications software more useful and easier to use (Averboukh, 2001); (Nunes, 2006).

According to ISO 13407 (ISO 13407, 1999), there are four key activities related to user-centred design, which should be planned and implemented in order to incorporate the requirements of usability in the process of software development (see Figure 3). The activities aim to:

- Understand and specify context of use;
- Specify the user and organizational requirements;
- Produce design solutions;
- Evaluate design against requirements.

These activities are performed iteratively, with the cycle being repeated until the usability goals have been achieved.

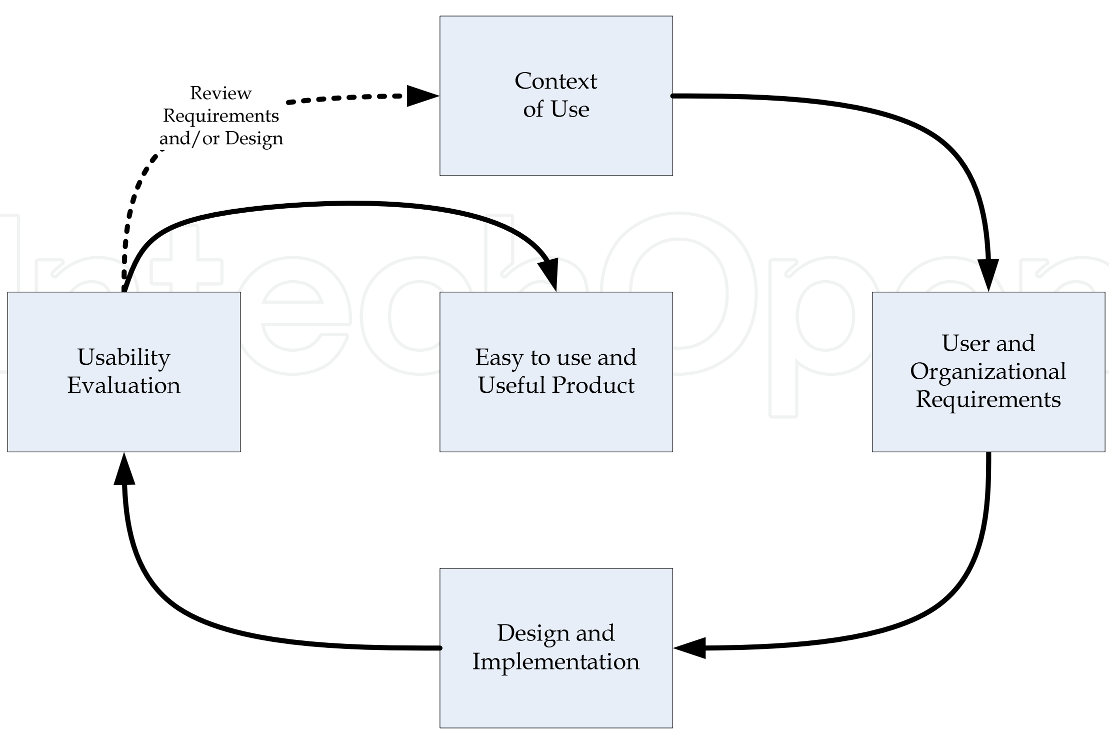

Fig. 3. Activities of user-centred design, adapted from ISO 13407 (ISO 13407, 1999).

According to (Howarth et al., 2009), the Usability Engineering process, which aims to implement the activities mentioned above regarding usability evaluation, includes (Figure 4):

- Identify and record critical usability data;
- Data analysis;
- Preparing the report of the evaluation results.

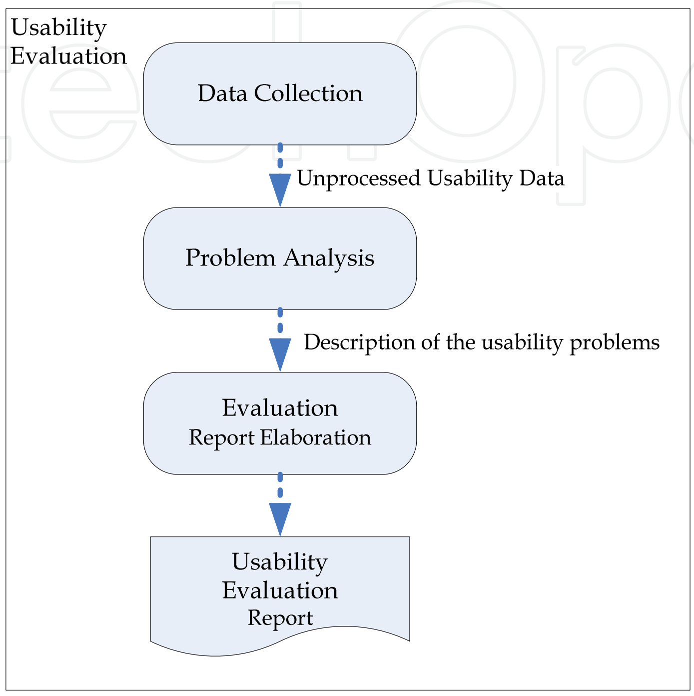

Fig. 4. Usability Evaluation, adapted from (Howarth et al., 2009).

In the section below that discusses guidelines and best practices are some recommendations on testing procedures, and reporting on the description of usability problems.

5. Methodologies and tools to support user-centred design

Usability analysis can occur at various stages of the development of a product (i.e., design, development and after implementation), although, hopefully, this analysis must be present at all stages, and should be iterative, allowing a continuous evolution of product quality.

There are several possible approaches to evaluate the usability, based, for example, on observation of users, application of questionnaires to users or analytical methods. The observation can be made in laboratory, but since the context of use is very important in usability studies, performing the study in the working environment where the system is intended to be used should be considered.

The assessment should draw on a representative sample of users for whom the system was designed.

Table 1 shows and describes a set of methodologies and tools for evaluating the usability considering, namely the phase(s) of development to which they apply, the amount of resources they require and how they are applied (based on (Usability Partners, 2011)). In this source, which offers a more complete list of tools or methods (in a total of 38 alternatives) it is possible to notice that most of the tools/methods are dedicated to a specific phase of project development (8 for the design phase, 10 for the preliminary design and prototyping, and 8 for the test phase and evaluation), 11 methods can be applied in two different phases, and only one (group discussion) is suitable to be applied in three phases.

Considering the early design and prototyping phase, the introduction of software development packages containing strong tools for developing the user interfaces, made easier and faster the prototyping of the graphical user interface (GUI) and of the basic interaction functionalities, turning almost obsolete other prototyping methods such as the paper- or video-based prototyping. Naturally, having real GUI prototypes helps the task of evaluating the usability of the products.

It should also be considered that there are many commercial support tools available to aid Usability Engineering activities. In most cases they are platforms for processing observational records. Some examples are:

- Morae, from TechSmith Corporation's (http://www.techsmith.com/morae.asp);
- Logger Egg, from Egg Studios LLC (http://www.ovostudios.com/ovologger.asp);
- Spectator, from BIOBSERVE GmbH (http://www.biobserve.com/products/spectator/index.html);
- Remote Usability Tester, from Pidoco (https://pidoco.com/en/benefits/products/remote-usability-tester).

Tool/Method	**Stage in development**			**Resources required (Low, Med., High)**	**Purpose/ Strength**	**Summary Description**
	Context & user requirements	**Early design & prototyping**	**Test and evaluation**			
Brainstorming		X		L	Produce design ideas	This is a group creativity technique (Osborn, 1953) by which a group of experts meet seeking to spontaneously generate new ideas by freeing the mind to accept any idea that is suggested. At the end a set of good ideas is generated.
Cognitive workload			X	L	Assesses if mental effort is acceptable	Cognitive workload (mental effort) can be measured subjectively using questionnaires which ask users how difficult they find performing a specific task. Examples of questionnaires are Subjective Mental Effort Questionnaire (Zijlstra, 1993) and the Task Load Index (NASA, 1986).
Cognitive walkthrough		X	X	M	Checks structure and flow against user goals	Cognitive walkthrough (Wharton et al., 1994) is a usability inspection method whose objective is to identify usability problems, focusing on how easy it is for new users to accomplish pre designed tasks. The reactions/comments of the users as the walkthrough proceeds are recorded.

Table 1. Examples of methods & tools for user-centered design, adapted from (Usability Partners, 2011).

Tool/Method	Stage in development			Resources required (Low, Med., High)	Purpose/ Strength	Summary Description
	Context & user requirements	Early design & prototyping	Test and evaluation			
Context of use analysis	X			L	Specifies user, tasks and environment characteristics	Context of use analysis (Thomas & Bevan, 1996) is a technique used for eliciting detailed information on user, tasks and environment. This information is collected during meetings of product stakeholders, which should occur early in the product lifecycle. The results should being continually updated and used for reference. Questionnaires can be used to evaluate current systems as an input or baseline for development of new systems.
Eye-tracking			X	H	Analyzes how users look at parts of an interface	Eye-tracking is a procedure for measuring either the point where we are looking or the motion of an eye relative to the head, using an eye tracker (Nielsen & Pernice, 2009). This method can be used to detect what users look at when interacting with an interface.
Heuristic evaluation		X	X	L	Provides feedback on user interfaces	Heuristic evaluation is a usability inspection method that helps to identify usability problems. It involves users, at least three, looking at an interface and judging its compliance with recognized usability principles/guidelines (the "heuristics"). The most well know heuristics are Nielsen Heuristics (Nielsen, 1994). Often the users are asked to rank the identified usability problems in terms of severity.
Task analysis	X			M	Analyses current user work in depth	Defines what a user is required to do (actions and/or cognitive processes) to achieve a task. A detailed task analysis can be conducted to understand a system and the information flow within it. Failure in performing this activity increases the potential for costly problems in the develop-ment phase. Once the tasks are defined, the functionality required to support the tasks can be accurately specified.
SUMI - Software Usability Measurement Inventory			X	L	Provides an objective way of assessing user satisfaction with software	SUMI is a method of measuring software quality from the end user's point of view (Kirakowski, 1994). Is based on a psychometric questionnaire (with 50 statements) designed to collect subjective feedback from users. The SUMI data is analysed by a program called SUMISCO. The raw question data is coded, combined, and transformed into a Global subscale, and five additional subscales: Efficiency, Affect, Helpfulness, Controllability, and Learnability. SUMI is mentioned in the ISO 9241 as a recognised method of testing user satisfaction. It is translated into several languages, for instance to Portuguese (Nunes & Kirakowski, 2010).
WAMMI - Web site Analysis and Measurement Inventory			X	L	Provides an objective way of assessing satisfaction w/ a web site	WAMMI measures user-satisfaction by asking website users to compare their expectations with what they actually experience on the website. It is based on standarised 20-statement questionnaire. This method uses five key scales: Attractiveness, Controllability, Efficiency, Helpfulness and Learnability and an overall Global Usability Score for how well visitors rate the website (http://www.wammi.com/index.html).

Table 1. (cont.). Examples of methods & tools for user-centered design, adapted from (Usability Partners, 2011).

Nowadays new types of interface technology and forms of interaction are gaining importance, for instance touch and multitouch screens and gestures interaction devices. The use of touch screens has several potential benefits, usually because they are intuitive, easy to use and flexible, reducing the need of other input devices (e.g., keyboards, mouse). Touch screens are particularly adequate for devices that require high mobility and low data entry and precision of operation. This is typically the case of tablets and smartphones. Other examples of applications where touch screens are gaining terrain are information kiosks or checkout terminal.

However, designing for touchscreens presents some usability challenges. For instance, designers must take into account issues such as: fingers/hand/arm can hide the screen, the lack of tactile feedback, the parallax error resulting from the angle of view or the display may be overshadowed by dirt, stains or damage on the screen or on the protective film.

To the best of our knowledge, currently there is no usability assessment methodologies specifically developed to this type of interfaces. This fact has not prevented the usability studies multitouch devices, such as the studies by Budiu and Nielsen (Budiu & Nielsen, 2011) on the usability of applications iPad. These studies were based on methods commonly applied to other types of screens. Also (Heo et al., 2009) analyzing the question of usability of mobile phones covers a range of issues that are relevant also for other emerging interfaces such as touch and multitouch screens.

Guidelines \ Reference	**(Haywood & Reynolds, 2008)**	**(HHS, 2006)**	**(Lea, 2011)**	**(Microsoft, 2009)**	**(MSDN, 2011)**	**(Sjöberg, 2006)**	**(Waloszek, 2000)**
Touch	X		X	X	X	X	X
Multitouch			X	X	X		
Multi-users				X			
Mobile Devices	X						
Web Design		X					
Controls Usage	X	X		X	X	X	X
Controls Dimensions	X	X	X		X	X	X
Controls layout and spacing		X		X	X	X	
Interaction			X	X	X	X	X
Touch gestures			X	X	X		X
Error Tolerance					X		X
Screen layout	X	X		X		X	X
Feedback			X	X		X	X
Biomechanical considerations			X			X	
Design process & Usability Testing		X					

Table 2. Summary of references containing Guidelines applicable to touch and multitouch devices.

6. Guidelines and good practices

As previously mentioned, the use of touch devices, and particularly multitouch is recent and not yet widely adopted by most users. Despite the touch devices are common in kiosks or cash registers, the set of applications used and the requirements that have to obey is reduced. Therefore, the body of references that discuss generic usability for multitouch devices and present guidelines and best practices for the design of applications is still not significant. Despite this limitation, some references applicable to touch and multitouch devices that offer recommendations on basic features for these interfaces is presented in Table 2. The type of references differs significantly, as well as their emphasis on different types of interfaces. For instance, Microsoft (2009) and MSDN (2011) focus on touch applications. (HHS, 2006) is not specifically dedicated to touch interfaces, is a compilation of about 500 general guidelines to consider in developing applications, including the ones devoted to Web environments.

In addition to these references, others such as (Largillier et al., 2010) and (Meador et al., 2010), discuss the evaluation of characteristics of multitouch devices but are not exclusively focused on the guidelines perspective.

Tables 3 and 4 offer other elements that might be relevant to specific aspect of usability evaluation, namely related with usability testing and usability problem reporting as suggested by (Kreitzberg & Little, 2009) and (Capra, 2006).

About the Tests	About Reporting Process
1. Decide what to test & develop test objectives; 2. Decide the type of participant in the tests and how many people to recruit; 3. Decide on the tasks and to use an experimental design and produce a script; 4. Decide if video recordings are made. If so, consider the need for a consent form; 5. Consider a questionnaire pre- and post-test and an introduction and debriefing interview; 6. Recruit & schedule participants' involvement; 7. Test the script, and materials to make sure that the testing process will run smoothly; 8. Perform the Testing; 9. Analyze results and prepare the report and recommendations.	Reports on Usability testing should cover: 1. The objectives of the test and an executive summary; 2. As participants were recruited; 3. Description of the tasks of the project and the test facility used; 4. The main problems found and recommendations to address them; 5. Small problems discovered and recommendations to address them; 6. Direct quotations of participants; 7. Recommendations and next steps.

Table 3. Recommendations for testing Usability, adapted from (Kreitzberg & Little, 2009).

• Be clear and precise, avoiding long words and jargon:	• Define the terms used, and be concrete, not vague; • Be practical and not theoretical; • Use descriptions of what people do not like to experts in HCI; • In the description avoid as details that no one wants to read; • Describe the impact and severity of the problem; • Describe how the task affects the user; • Describe how often the problem occurs, and the components that are affected.
• Base the findings on data	• State how many users experienced the problem and how often; • Include objective data, both quantitative and qualitative, such as the number of times a task was attempted or the time spent on task; • Provide traceability of the problem in the observed data.
• Describe the cause of the problem	• Describe the main usability issue involved in the problem; • Avoid assumptions about the cause of the problem or the thoughts of the user.
• Describe the actions the user observed	• Include background information about the user and the task; • Include examples, such as user navigation flow through the system, user's subjective reactions, screenshots, and success / failure in performing the tasks; • State whether the problem was user reported or experimenter observed.
• Describe a solution to the problem	• Offer alternatives and tradeoffs; • Be specific enough so as to help but without imposing a solution; • Complementary to the principles of design for usability.

Table 4. Guidelines to describe Usability problems, adapted from (Capra, 2006).

7. Conclusions

Usability is a critical aspect to consider in the development cycle of software applications, and for this purpose, user-centred design and usability testing must be conducted. The design and testing cannot ignore the context of use of software, whose knowledge is essential.

Usability of a system is characterized by its intuitiveness, efficiency, effectiveness, memorization and satisfaction. Good usability allows decreasing the time to perform tasks, reducing errors, reducing learning time and improving system users' satisfaction.

Usability, process design and development of software have necessarily to be framed by the characteristics of users, tasks to perform and environmental context (social, organizational and physical) for which the product is intended to.

The development of a product must consider the 10 basic usability principles: consistency, compatibility, consideration by the resources of the user, feedback, error prevention and error recovery, user control, clarity of vision, prioritization of functionality and information, appropriate technology transfer, and clarity.

There is a wide range of tools and methodologies for identifying and evaluating the usability of a system, thus contributing directly or indirectly, for its improvement. The selection of these tools and methodologies depends on the objective to achieve, which usually is related to the development phase the system is in. Some approaches are better suited to the design stage (e.g., analysis of context of use and task analysis), while others are more suited to early stages of development and prototyping (e.g., brainstorming, prototyping) and others for the evaluation and testing (e.g., analytical and heuristic evaluations, SUMI).

Finally, in developing a solution one has to consider the guidelines and best practices that are relevant, taking into account the specific context. There is a vast literature on generic guidelines for usability. As mentioned, the body of reference for touch and multi-touch interfaces is very limited, since this is a quite new type of user interface. Nevertheless there is a significant number of sources and formal or industrial standards that may be adopted.

8. Acknowledgments

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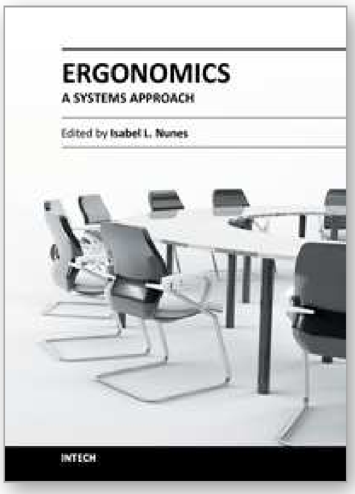

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This book covers multiple topics of Ergonomics following a systems approach, analysing the relationships between workers and their work environment from different but complementary standpoints. The chapters focused on Physical Ergonomics address the topics upper and lower limbs as well as low back musculoskeletal disorders and some methodologies and tools that can be used to tackle them. The organizational aspects of work are the subject of a chapter that discusses how dynamic, flexible and reconfigurable assembly systems can adequately respond to changes in the market. The chapters focused on Human-Computer Interaction discuss the topics of Usability, User-Centred Design and User Experience Design presenting framework concepts for the usability engineering life cycle aiming to improve the user-system interaction, for instance of automated control systems. Cognitive Ergonomics is addressed in the book discussing the critical thinking skills and how people engage in cognitive work.