

Consolidating the ISO Usability Models

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ABSTRACT

In recent years software usability has become a major research theme in the software engineering community. Up to now, only a few software quality models address the usability evaluation and measurement in a detailed and structured way. The International Organization for Standardization (ISO) developed a variety of models to measure software usability, but none of these models cover all usability aspects. Furthermore, they are not part of the current software engineering practices and no tool exists to support it.

The motivation of this research is to address these limitations by proposing a consolidated, normative model for the evaluation of software usability.

Keywords

Software usability, standards, models, ISO 9241-11, ISO 9126, measurement

1 INTRODUCTION

“American industry and government will become even more productive if they take advantage of usability engineering techniques” [1]. During the last two years, a major change in the way software is designed occurred. With the considerable growth of the distributed applications, driven by the Internet, the developers have no longer a direct feedback from the user of the systems. In this context, usability analysis is no longer an optional development item, but a required step enabling future software acceptance. Without a direct access to the end-user, designing a software system with a good usability and a good learnability is a significant challenge for the developer and a key issue of the software quality..

This paper first presents a survey and an evaluation of current ISO usability standards and related research of the domain. The main contribution of this research is a synthesis of current ISO models for evaluation of software usability such as ISO 9241-11 and 9126..

The second section of the paper presents a survey of usability definitions. The third section, a discussion of usability standards ISO/IEC 9126 and ISO 9241, identifying advantages and inconveniences of them. The fourth section propose a consolidated model and the fifth section, additional recommendations for the model. The motivation behind this exploratory research is to enhance user productivity. By improving the evaluation of the software usability, the user shall consequently faster and better understand the software and gain in productivity.

2 BACKGROUND

2.1 Usability definitions

The concept of usability refers to the execution time, the user satisfaction and the user’s ease of learning. Usability is not defined homogeneously by researchers and standardization organisations. Table 1 illustrates how the concept of usability is defined in different standards:

Table 1: Usability definitions in Standards

USABILITY'S DEFINITIONS
<p>➤ ISO/IEC FCD 9126-1, 1998 :</p> <p>«The capability of the software product to be understood, learned, used and attractive to the user, when used under specified conditions.»</p>
<p>➤ ISO9241-11, 1998 :</p> <p>«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.»</p>
<p>➤ IEEE Std.610.12-1990 :</p> <p>«The ease with which a user can learn to operate, prepare inputs for, and interpret outputs of a system or component.»</p>

The challenge when defining usability is to specify its characteristics and its attributes, because they vary and depend on the context in which the product is used.

Standards related to usability can be classified along the following categories (Figure 1):

1. Product effect (output, effectiveness and satisfaction at the time of use of the product);
2. Product attributes (interface and interaction);
3. Process used to develop the product;
4. Organizational Capability.

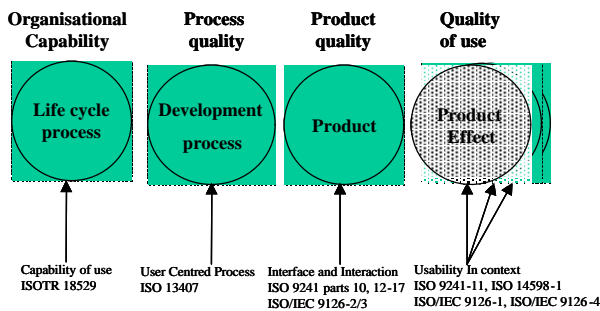


Figure 1: ISO usability standards [84]

Standards on usability can be classified in two categories:

1. Product oriented standard (ISO 9126 and ISO 14598)
2. Process oriented standard (ISO 9241 and ISO 13407)

Software usability can be characterized by different properties, depending on the target audiences of the usability analysis of the systems. Candidate audiences include end-users, managers and software developers. Each of these audiences has a specific vision of the usability:

1. For the end-user, software usability condition its performance: an application that features good usability allow him to achieve the expected task, faster and more efficiently.
2. For the manager, usability influence his decision when choosing a product.
3. For the software developer, usability dictates the internal attributes of the system, covering issues like quality of design, completeness of documentation and maintainability of the software.

This diversity of viewpoints, and the related usability requirements, create different perspectives of usability among the different ISO models, developed over years by different expert groups. Unfortunately, each group build its model without the inputs of other groups. Consequently, different terms or labels for the same usability characteristics appear. An example of this inconsistency across standards, is the definition of "learnability": in ISO 9241-11, "learnability" is a single attribute meaning "time of learning" but in ISO 9126 it encompass several attributes such as "comprehensible input and output, instructions readiness, messages readiness, etc."

This illustrates that further work is required to converge and bring consensus in the community on the definition of usability that integrate all viewpoints into a unified model.

This paper focus mainly on ISO 9241 and ISO 9126. Identification of the strengths and weaknesses of each standard will be the basis of the proposed consolidated model.

3 USABILITY IN ISO STANDARDS

3.1 ISO 9126

ISO 9126 address software quality from the product point of view. It is probably the most extensive software quality model, even if it is not exhaustive. Initially published in 1991, The approach of its quality model , is to present quality as a whole set of characteristics. It divides software quality into six general categories: functionalities, reliability, usability, effectiveness, maintainability and portability (figure 2).

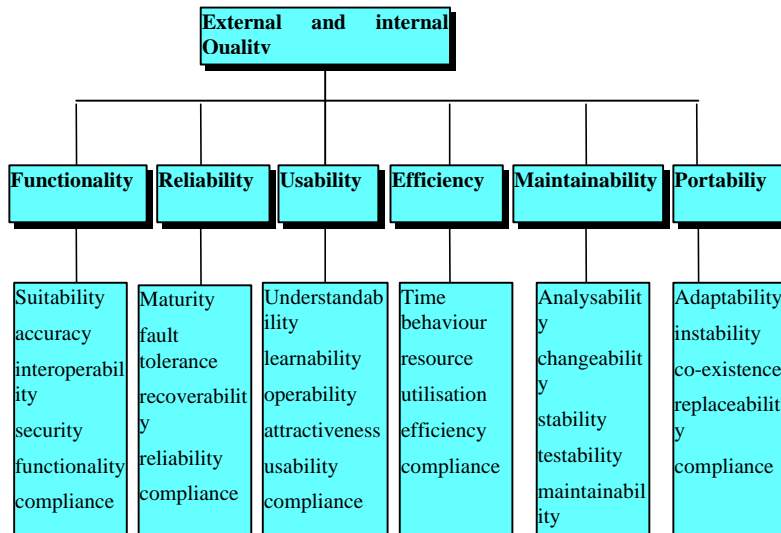


Figure 2: Software Quality – ISO 9126

The objective of this standard is to provide a framework for the evaluation of the software quality, but not to provide requirements for software., The quality model can be applied to all kind of software.

This decomposition reflects the users' view and introduces the concept of quality in use.

The 2000-2002 edition of ISO/IEC 9126 is divided into four parts:

1. ISO/IEC 9126-1: Software Engineering - Product quality - Part 1: Quality model (2000).:

This section of the standard specifies a model in two parts for quality:

- a) Internal and external quality model is defined with six characteristics: functionality, reliability, effectiveness, usability, maintainability and portability.
- b) Quality in use model is defined with four characteristics: Effectiveness, productivity, security and satisfaction.

2. ISO/IEC 9126-2: Software Engineering - Product quality - Part 2: External metric¹s (2000).

This section describes measures used to specify or evaluate the behaviour of the system when operated by the user.

3. ISO/IEC 9126-3: Software Engineering - Product quality - Part 3: Internal metrics (2000).

This section describes measures used to specify or evaluate the static properties of the interface. Measure done by inspection that doesn't involve operating the system.

¹ The term “metric” used in ISO/IEC 9126, is being consecutively replaced by “measure”

4. ISO/IEC 9126-4: Software Engineering - Product quality - Part 4: Usability metrics (2002).

This section describes measures used to evaluate the usage of the software by the user.

The objective of the standard is to provide a model for evaluation of the software quality. ISO/IEC 9126 does not specify quality requirements, but it defines a model generic enough to be applicable to many kind of software.

3.2 USABILITY IN ISO 9126

In 1991, ISO 9126 defined the usability as "A set of attributes that bear on the effort needed for use and on the individual assessment of such use, by a stated or implied set of users" [2]. It proposed then a product oriented usability approach. Usability was seen like an independent factor of software quality. It treated software attributes, mainly its interface that makes it easy to use.

However the attributes that a product requires for usability depend on the nature of user, task and environment. In a product oriented approach, usability is seen as a relatively independent contribution to software quality, as defined now in the 2000 edition of ISO/IEC 9126-1: "The capability of the software product to be understood, learned and liked by the user, when used under specified conditions".

Usable products can be designed by incorporating product characteristics and attributes to users' benefits in particular contexts of use. Users are interpreted directly as interactive system's users. They can include operators, direct or indirect users who are influenced or depend on the software use.

Usability should address several user environments that the software can affect, including both use preparation and results evaluation. Usability is defined in this international standard as a specific whole of software attributes; it is different and defined from an ergonomic point of view with other characteristic such as output and effectiveness as usability components.

To specify software quality, a purchaser needs a model and analytical tools to communicate precisely his requirements concerning the product to develop. Similarly, a software provider needs to be able to evaluate with confidence if the product provides the expected level of software quality. This ISO 9126 standard can be used a reference for contractual agreements between a purchaser and a software producer and it can be used to eliminate a number of misunderstandings between purchaser and provider.

The principal advantage of a clearly defined and agreed upon model, supported with related measures, is that it clarifies usability definition, and objective evidence of achievement can be obtained through specified measurements. It is to be noted that during the development process, including testing, measurements are usually collected in simulated environments of laboratory, where industrial context may be lost.

Model ISO/IEC 9126 can be used to specify, and verify, these properties that the software must exhibit before being in service. It has been and referred and used. Some countries, such as, Japan have adopted it as a national standard.

However, there are still some weaknesses in ISO 9216 that have not yet been fully tackled, such as:

- Unclear architecture at detailed level measures;
- Some overlapping of concepts challenging to be grasped clearly by the user community, such as the usability characteristics of internal and external quality with respect to the quality in use set of quality characteristics.
- Lack of quality requirements standard;
- Lack of guidance in assessing results of measurement;
- Choice of measures is ambiguous.

Also, the model is static, that is doesn't not describe how to project the metrics from current values to values at subsequent project milestones. It is important to be able to relate software metrics to progress and to expected values at the time of delivery of the software, and do not give any guidance as to the use of the metrics and attributes in the identification and classification of risk[3].

3.3 ISO 9241

ISO 9241 is a series of international standards of ergonomics requirements for office work with visual display terminals (Figure 3). The definitions of Part 11 of ISO 9241 are built from a different usability viewpoint. Its key components are: effectiveness that describes the interaction from a process point of view, efficiency that is the attention for results and resources implied and satisfaction that refers to a user point of view.

ISO 9241 provides requirements and recommendations concerning hardware, software and environment attributes that contribute to usability, and subjacent ergonomic principles. Parts 3 to 9 deal with hardware design requirements and guidelines that can have implications on software. Parts 10 to 17 deal with software attributes.

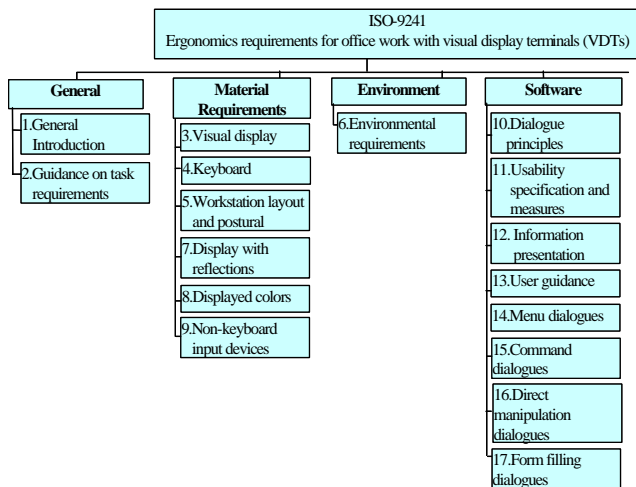


Figure 3: The 17 Parts of ISO 9241

3.4 USABILITY IN ISO 9241

Part 11 of this standard explains how to identify the information that it is necessary to take into account when specifying or evaluating usability in terms of measures of user performance and satisfaction. Guidance is given on how to describe the context of use of the product and the measures of usability in an explicit way [10]. In spite of the name, the definitions of part 11, Usability guideline, are also known to be applicable to other situations where a user interacts with a product to achieve certain objectives. This extension makes usability a general concept likely of application outside its conventional applications in information technology.

The standard ISO 9241 defines the usability in the following way: Software is usable when it allows the user to execute his task with effectiveness, efficiency and satisfaction in the context of use specified.

According to this standard, the measurement of system usability consists of three usability attributes:

1. Effectiveness: How well do the user achieve the goals they set out to achieve using the system?
2. Efficiency: The resources consumed in order to achieve their goals.
3. Satisfaction: How the users feel about their use of the system [5]?

This standard presents usability guidelines, is very used for evaluating usability according to the context of the software. However, it is very difficult to specify how system's characteristics and attributes should be, because their nature depend on the context of use. Moreover, there is not an evaluation technique more recommended than others, since the result from an evaluation are closely dependent on the application context and evaluation objectives.

ISO 9241-11 recommends a process oriented approach for usability, by which the usable interactive system is achieved through a human centred design process.

Usable products can be designed by incorporating characteristics and attributes in particular contexts of use. This process alone is not sufficient to ensure efficiency, effectiveness and satisfaction by using the product. To verify the achievement of the level of usability required, it is necessary to measure the performance and the satisfaction of users working with the product. The measurement of usability is a complex interaction between users and context of use; this might produce different levels of usability performance for the same product when it is used in different contexts.

Context characteristics (users, tasks and environment) can be significant to determine usability as a product characteristic: a change in any relevant aspect of context of use can change product usability. For example, user interface can be improved by conformance to good practices of dialogue design, by ensuring harmony between user and system, through selection and users' training or through good design of task. A product that is usable by qualified users might not be usable by beginners. Work environment's aspects, such as noise or office design, can also affect the usability.

The approach adopted in Part 11 of ISO 9241 has the following advantages:

1. ISO 9241-11 model identifies usability aspects and context of use components to be taken into consideration during specification, design and usability evaluation;
2. User's performance and satisfaction provide direct measurements of usability in a particular context;
3. User's performance and satisfaction measurements provide a base for comparison between usability and other design features for the same context;
4. Usability can be defined and verified within quality system conformant to ISO 9001.

On the other hand, this standard has also some weaknesses:

1. It addresses usability strictly from a process viewpoint; it therefore tackles only a viewpoint;
2. ISO 9241-11 does not tackle the learnability characteristic recommended by the majority of standards and experts on usability;
3. It does not tackle the security aspects, considered to be very significant by experts in evaluating software usability.

In deed, the normative models are not yet easily exploitable for usability evaluation, because users need very clear demonstration to apply these models on their software. Similarly, issues of usability at the architecture level are among the most difficult to rectify because changes at this level are inevitably propagated to the dialogues and presentation level.

4 A CONSOLIDATED MODEL

In this section, we present now our suggestions for improving the current ISO usability models. The analysis of the definitions of ISO 9241 definition indicates that this standard has a broader perspective of usability than ISO 9126: ISO 9241 focuses on tasks and environment questions as organisational factors and its usability definition on software quality characteristics that are distinct from those of usability in ISO 9126, such as functionality, precision and effectiveness. All these characteristics contribute to software quality.

The two viewpoints on usability are complementary to each other: according to Bevan, the interactive system does not have intrinsic usability, only an ability to be used in a particular context of use. For example, 9241-11 can help us to understand in which context particular attributes specified in ISO 9126 are required.

In the table (Table 2) below we summarise the points that explain our choice for ISO 9241-11 as the basic architecture for our consolidated model.

Table 2: ISO 9241

➤ The only normative model that treats usability itself.
➤ Adopted by experts in HCI (Human Computer Interaction) For example: Jordan and Al 1996b.
➤ Explains how to identify information for specifying or evaluating usability. Guidance given to describe product context of use (hardware, software or service) and required measurements for usability with explicit manner
➤ Considered by experts to be the best-suited instrument to interpret the VDU directive. Also accepted by the EU commission as a vehicle to demonstrate compliance with the directive. The standard is harmonised in Europe and published as a German DIN standard. [6].
➤ Defines the usability on the basis of 3 characteristics: Effectiveness, efficiency and satisfaction (the most representative points in the general case).

However, some researchers have proposed their own model of usability, through definitions or attributes of this concept, including often the **learnability** characteristic for usability. This is illustrated in Table 3, figure 5.5 and figure 5.6.

Table 3: Learnability as a usability characteristic

➤ Nielsen and Schneiderman characterized five attributes of usability: learnability , effectiveness, tolerance with errors, satisfaction and memorizing.
➤ Boehm defined software usability as, the width to which the product is convenient and practical to use .
➤ Capers Jones: usability is the total effort required to learn , operate and use software or hardware
➤ Gilb identifies some measurable attributes of usability; one of them is learnability .
➤ Model ISO/IEC FCD 9126-1 defines of usability as the capacity of the software product to be included/understood, learned , used and attracting with the user, when it is used under specified conditions.
➤ IEEE Std. 610.12 defines of usability as the ease with which a user can learn how to operate, prepare inputs, and to interpret the outputs of a system or component.
➤ The MUSiC project identifies learnability as attribute of usability.

The figure 5.5 presents software usability evaluation model realised by Dix.

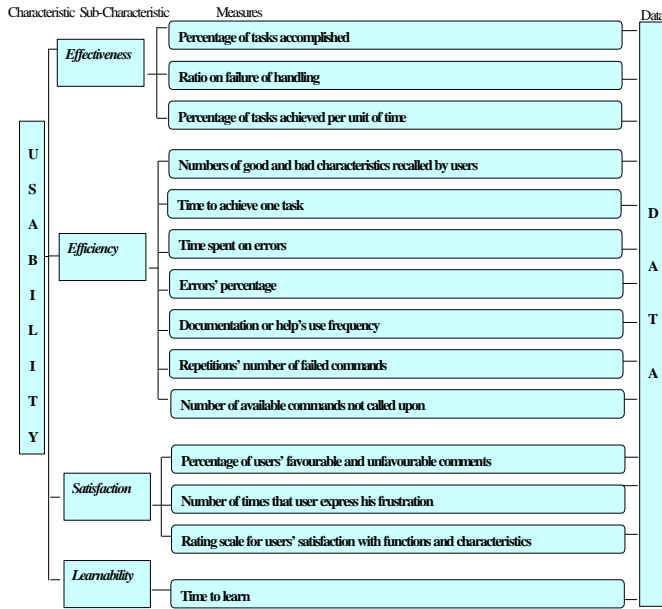


Figure 5.5: Usability Model (Dix et al [12])

The figure 5.6 presents software usability evaluation model realised by Nielsen.

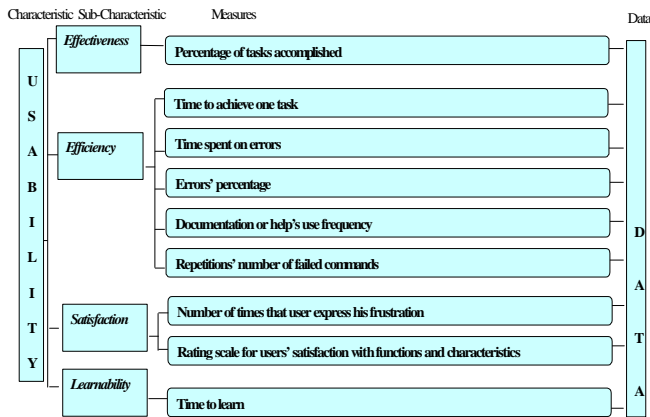


Figure 5.6: Usability Model (Nielsen et al [17])

Other researchers as well as other standards organisation have also identified other viewpoints on usability, and an additional characteristic is identified called **security** characteristic (Table 4).

Table 4: Security as a Usability Characteristic

➤ ITSEC: Information Technology Security Evaluation Criteria.
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➤ Standard IEC 300 present software critical- security .
➤ ISO 13407 (1999) describe Human centred design as a multidisciplinary activity that incorporates human factors and ergonomic and technical knowledge with the objective to raise efficiency and effectiveness, to improve human working conditions, and to oppose possible unfavourable effects of use on human health, security and performance.
➤ ISO/IEC 9126 defines Security which is sub-characteristic as, a set of software attributes which relate to its ability to prevent unauthorized access, even if accidental or deliberated, to programs and data.
1. Security is a characteristic of the CHI particularly important in industrial context [7].

In fact, good usability is a significant condition for the human security in critical systems, such as medical apparatuses, or nuclear power stations. For this reason, the standardisation community has established standards for security in information technology field (See Table 4).

From the information in these summary tables, and the fact that ISO 9241-11 is process oriented; therefore it does not address other views. We suggest that the ISO 9421 usability model can be revised to include the other two key usability sub-concepts which are learnability and security, as shown in Figure 4.

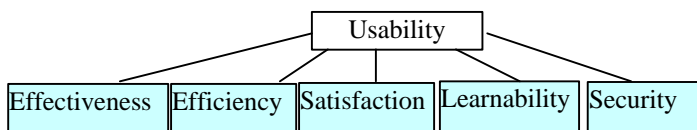


Figure 4: Revised Usability Model

Through this model we will focus usability objectives on most significant tasks of users, it's practical approach, although it means that we will be unaware of some functions. The model hierarchy of ISO 9126 with its three layers (characteristics, sub-characteristics and measurements) will be used next, to structure the models proposed by various authors, and to identify the components to be integrated into a consolidated model.

The figures 5.5, 5.6 and 5.7 present the various details of the usability models of three groups of authors: Dix et al. [4], Preece[8] and Nielsen et al. [9]. The figure 5.8 illustrates our consolidated model.

The figure 5.7 presents software usability evaluation model realised by Precece.

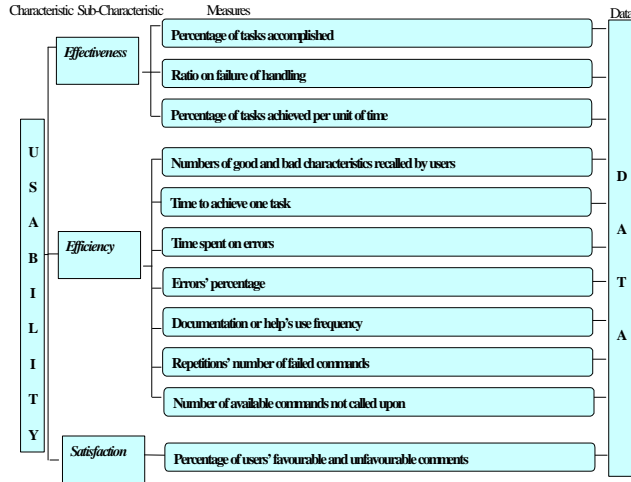
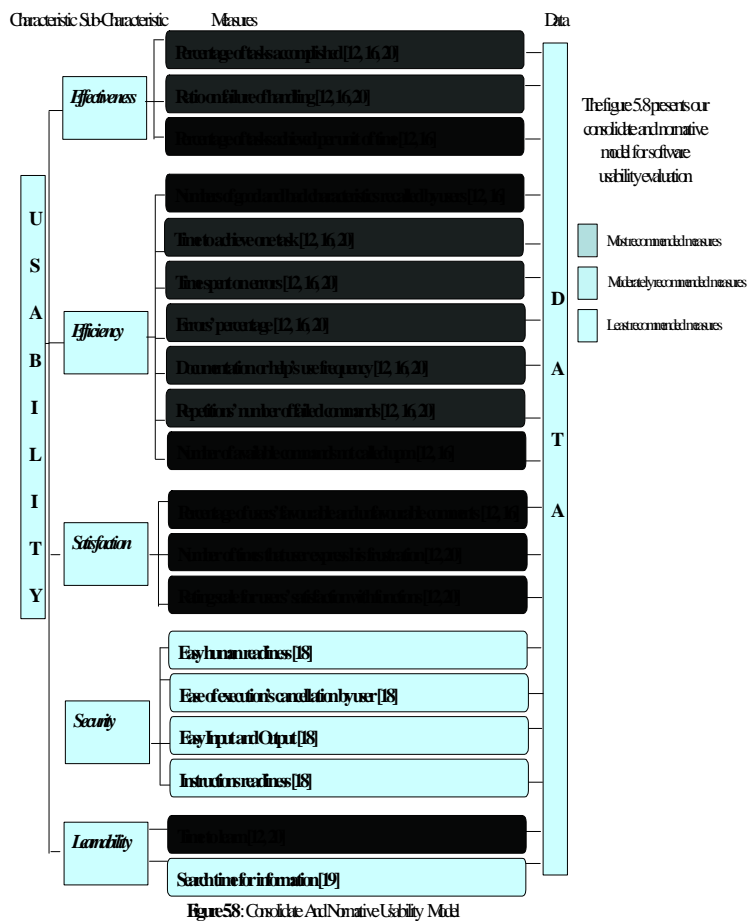


Figure 5.7 : Usability Model (Precece [16])

On the basis of this structure as well as from the various details presented by various authors, they can now be combined together to take into account the various concepts and sub-concepts proposed by these authors as relevant to the usability concept. This consolidation is presented in Figure 5.8, which in addition provides an indication on whether the measures proposed at the third level of the model have been quoted by most authors, or not.



5 CONCLUSION

Usability is an important factor for determining software quality. This study has investigated various models for software usability, in particular the ISO models. It was highlighted that the ISO standards have not been designed from the same perspective; similarly, definitions given by experts and researchers had not yet been harmonized. This is a confirmation that the current models of usability are not yet mature and that further work is required to develop a greater consensus on an improved and more comprehensive model.

For instance, the model of usability ISO 9241-11 was developed by a group of experts specialized in Computer Human Interaction whereas the model ISO 9126 was developed by another group of experts specialized in software engineering.

On the basis of strengths and weaknesses analysis of both standards, as well as on investigation of other models proposed by various authors, a revised structure for a usability model was proposed, including two additional characteristics to the initial ISO 9241-11 standard: "learnability" and "security". Then specific measures for these characteristics were presented using the structured hierarchy of ISO 9126.

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