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► To cite this version:

Ahlem Assila, Houcine Ezzedine, Káthia Marçal de Oliveira, Mohamed Salim Bouhleb. Towards improving the subjective quality evaluation of human computer interfaces using a questionnaire tool. 2013 International Conference on Advanced Logistics and Transport (ICALT), May 2013, Sousse, Tunisia. pp.275-283, 10.1109/ICAdLT.2013.6568472 . hal-03472778

HAL Id: hal-03472778

<https://uphf.hal.science/hal-03472778v1>

Submitted on 21 Nov 2022

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Towards improving the subjective quality evaluation of Human Computer Interfaces using a questionnaire tool

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Abstract—the quality evaluation topic of human computer interfaces is increasingly attracting researchers' attention in the information system community. The quality subjective assessment of the interactive systems interfaces using the advanced technology is an important issue which merits attention from researchers. In order to increase the overall satisfaction of users, questionnaire tool is used as one of the main techniques dedicated to aid evaluators to measure users' perceived qualities. The purpose of this paper is to enhance the quality subjective assessment by defining a conceptual specification for a new automatic questionnaire generating tool able to collect, analyze and criticize the users' views. The developed questionnaire tool will be used in the context of evaluation of traffic supervision system in Valenciennes (France). The main contribution is to propose a web generation questionnaire environment to provide a subjective evaluation for the interactive systems interfaces. It includes the proposed questionnaire model and describes the applied subjective evaluation process based on ISO 14598 norms.

Keywords—HCI evaluation; quality; questionnaire tool; usability evaluation; evaluation process; interactive systems; ISO14598

I. INTRODUCTION

In the interactive systems life-cycle, system development should be passed across various design guidelines in order to ensure that the system can achieve the purposes and aims intended to be accomplished. Evaluation is the key to effective Human-Computer Interface design. Specifically, the quality evaluation is one of the main challenges faced by current Information and Communication Technology. The term quality is increasingly used in industrial field and

particularly in the computer word. ISO 8402-1986 standard defines quality as "the totality of features and characteristics of a product or service that bears its ability to satisfy stated or implied needs".

How to measure quality is an important question in Human-Computer Interface research and user interface evaluation. The interface quality of any interactive system can be evaluated and determined using the appropriate evaluation methods and techniques. Some methods such as the electronic cookies and the users' tests are objective tools, while others which known by the subjective tools are directed toward users in order to collect users' point of views, opinions and attitudes among them we quote the questionnaire tool.

In this paper, we are interested to enhance the quality assessment of the interactive systems interfaces based on the use of questionnaires. Questionnaires are useful tools to assess the interaction between the user and the interface. They are used to collect information on subjective data on user profiles, the quality of the interface and what are the problems encountered in its use [1]. Developing a questionnaire system for quality subjective evaluation which can meet the evaluators' requirements is a difficult issue. That's why; we are concentrated to suggest a web generation questionnaire environment to define the conceptual specification needed to develop a new automatic questionnaire generating tool able to provide a subjective assessment for the interactive systems interfaces. This environment includes the applied questionnaire model and a proposed subjective evaluation process based on ISO 14598 [2]. Considering that usability is one of the major factors that determine the successfulness of a system [3], we give a study of the necessary usability aspects needed to evaluate an interactive system and to design an efficient web questionnaire tool.

The paper is organized as follows. Section 2 reviews some related works on quality and usability assessment for interactive systems using subjective tools and specially the web questionnaires tool. Section 3 presents an overview of the existed HCI evaluation methods and techniques. Section 4 contains a detailed study of the usability aspects used to design an efficient web questionnaire tool. Section 5 explains our proposed web generation questionnaire environment to provide a subjective evaluation for the interactive systems interfaces. Section 6 draws conclusions and future work.

II. RELATED WORKS

Define the followed evaluation process during the conceptual specification of a quality evaluation tool of software is an important task. International standards have been focused on this subject as ISO9126 and ISO14598. In 1991, ISO (International Organization for Standardization) published its first international consensus on terminology used for quality characteristics for software product evaluation: ISO/IEC 9126-Software Product Evaluation-Quality Characteristics and Guidelines for their Use. Between 2001 and 2004, ISO published four complementary parts containing both ISO quality models (ISO/IEC 9126-1) and the inventory measures (ISO/IEC 9126-2, 3, 4). ISO9126 was recently integrated in a new standard, named SQUARE (2005). This version is complemented by a set of methodological guidelines ISO 14598 which is focuses on the evaluation process.

Designing new quality evaluation tools of HCI is crucial in order to enhance evaluation. Our choice is fixed to the questionnaire tool for improving the quality subjective evaluation of HCI. Indeed, the definition and development of such a tool, able to enhance the measurement of the users' subjective attitudes and judgments, is not a trivial task.

Over the past twenty years, several questionnaire models have been put forward by researchers. A diversity of web questionnaires have been used and reported in the literature for assessing the perceived usability of websites and systems. In what follows, we presents a collection of the most frequently used questionnaires tools which are specifically developed and designed to assess interfaces quality.

Software Usability Measurement Inventory (SUMI) is a generic usability tool proposed by Kirakowski et al [4]. It is the only commercially available questionnaire for assessing and measuring software quality from the end user's point of view. Also, it is an industry standard questionnaire for analyzing users' responses to desktop software or software applications provided through the internet and it is mentioned in the ISO 9241 standard as a recognized method of testing user satisfaction. In addition to that, it is available in various languages and it is existed in several versions: version 1.0 (1993) [5] until the current version named Software Usability Measurement¹ 4.0 (2011). This generic

usability tool is comprised of a validated 50-item paper-based questionnaire in which respondents score each item on a three-point scale (i.e., agree, undecided, disagree) [6]. SUMI is a solution to the recurring problem of measuring users' perception of the usability of software but it suffers from some drawbacks. This questionnaire is limited to measure only these criteria: the attractiveness, efficiency, learnability, helpfulness and control. It is updated each year; their comfortable number of users is between 10 and 12. Also, it does not fit any application type (it is designed for standard office-type applications). In addition to that, it cannot be changed according to a particular situation.

Purdue Usability Testing Questionnaire is known by PUTQ [7]. It is a standard questionnaire that has been dedicated to the measurement of software usability. It consists of 100 questions. Questions are based on the likert scale which is divided on seven points from bad until good. But, it is limited also to eight dimensions of usability: compatibility, consistency, flexibility, learnability, minimal action, minimal memory load, perceptual limitation and user guidance [8]. Furthermore, it is intended only to assess the usability factor.

Chiew and Salim [9] proposed a method focuses on websites issues and implements a web questionnaire tool for evaluating the usability of websites called WEBUSE (WEBSITE USABILITY Evaluation Tool). It contains 24 questions; the responses users to the questionnaire are analyzed. This tool generated a report which contains the analysis results and shows the good and bad usability aspects of the website. The researchers claim that WEBUSE is suitable for the evaluation of all types of websites and for any domain but it is only dedicated to the usability evaluation.

Ryu [10] developed an automatic tool to provide an effective subjective usability measurement tool, designed specifically to the mobile phone. It named Mobile Phone Usability Questionnaire (MPUQ). It is based on two approaches, firstly generate and judge measurement items for the usability questionnaire for electronic mobile products and secondly design and conduct studies to develop and refine the questionnaire. It can be considered as a complement to automated evaluation methods by providing user-centered values and emotional aspects of the product. However, this automatic tool fits only on the mobile phone products and it is not generic.

The Questionnaire for User Interface Satisfaction is known by QUIS [11]. It is a tool developed at the University of Maryland. QUIS was designed to assess user's subjective satisfaction with specific aspects of Human-computer interface. It is commercial and existed in several versions; version 1.0 which is the original version and it was composed of 27 questions, each question is a rating on a ten-point scale with appropriate anchors; version 2.0; version 3.0; version 4.0; version 5.0; version 5.5; version 6.0; version 7.0 which is the current version developed in 2011. It is designed to be configured according to the needs of each interface analysis by including only the sections that are of interest to the user. But, it suffers from the lack of standardization and validation data.

¹ <http://sumi.ucc.ie/en/>

To conclude, despite the existence of standardized questionnaires such as SUMI [5], which are dedicated to assess interfaces quality with a subjective manner, there are all focused on the usability factor without considering the other quality factors such as the accessibility, reliability, sustainability, etc.

Define a determined questions by the developers of questionnaires may not respond to evaluators requirements as well as it can be the reason of their dissatisfaction. That's why and in order to overcome these limitations, we intend to suggest a web generation questionnaire environment to define the conceptual specification needed to develop a new automatic questionnaire generating tool. This environment defines an automated evaluation process to provide better results than the other questionnaires.

The next section describes an overview of the existed HCI evaluation methods and techniques.

III. OVERVIEW OF THE EXISTED METHODS AND TECHNIQUES TO ASSESS THE QUALITY OF THE INTERACTIVE SYSTEMS INTERFACES

The interface quality of any system cannot be directly measured. It can be evaluated and determined using HCI evaluation methods and techniques. Over the past thirty years, several evaluation methods have been proposed to assess the quality of systems in order to suggest enhancements to the design systems by measuring the quality degree of interface systems. There are a large number of methods and techniques used for HCI evaluation. There have been several classifications methods. Table 1 illustrated the main existed classifications.

TABLE I. HCI EVALUATION METHODS AND TECHNIQUES

Authors	Proposed evaluation Methods and approaches classifications	
Senach[12]	2 categories	Empirical (Capture behavioral data)
		Analytical approach (Evaluate the design of the system and not their use)
Balbo[13]	3 categories	Automatic approach
		Semi-automatic approach
		Manual approach
Grislin and Kolski[14]	3 categories	User-centered approaches
		Approaches focusing on an expertise
		Approaches focusing on HCI modeling
Bastien and Scapin[15]	2 categories (based on data nature)	The direct participation of the user (Combine both methods user reports and observation methods)
		Method without direct interaction between the user and the system (Combine both analytical methods and expert reports)

Authors	Proposed evaluation Methods and approaches classifications	
Charfi and Ezzedine [16]	2 categories	Dynamic approach
		Static approach

There is no evaluation method more effective than the others; each method has advantages and drawbacks. Before evaluating a HCI, evaluators should choose the right technique or method. The choice of method among a bunch of techniques must be made taking into account the use situation and the criteria to inspect [17].

In this section, Grislin and Kolski classification [14] is adopted in order to present briefly the HCI assessment methods and techniques. This classification consists of 3 categories [14] [17] [18]:

A. User-centered approaches

This approach is based on the user observation techniques and the interaction data collection. These approaches are based on the collection and analysis of behavioral data from the use of HCI by the representative users of the final population [14]. It is an empirical approach and it includes 3 sub categories:

1) Use diagnostic Empirical approaches

This approach consists of evaluating a product as “a cycle corresponding to the iterative design process” [11]. It is a series of tests established on each product version until its achievement [17]. This approach contains several tools and techniques which can be subdivided into two classes. The subjective and the objective techniques:

a) The subjective HCI evaluation measures

- *Questionnaire*: This technique allows collecting the users' attitudes and judgments after interaction with the evaluated interactive system by asking the user on different aspects to measure the evaluated interface quality. It allows evaluators to retrieve the usability problems in a subjective way. There are several question types: closed questions, open questions and the scalar questions
- *Interview*: It is a technique that consists on meeting with representative users to obtain a first exploded view of utility and usability problems [17].

b) The objective HCI evaluation measures

- *Cookies*: This technique aims to collect automatically the objective data such as the user actions and their repercussions on the systems in a real work situation, and then analyzes it.

2) The workload estimation

This approach is based on the cognitive work estimation of the user. Estimating workload allows measuring the difficulty level associated with the use of HCI. It can be qualitative or quantitative. The methods for estimating the workload can be subjective (ask the user to estimate the workload with subjective scales) or objective (exploit a measured parameters to estimate the workload).

3) *The test design with users*

This approach aims to evaluate and validate an interactive system or a HCI in an iterative cycle throughout the development process. The tests include three complementary design approaches [19]: The prototyping, design selection alternatives and the final test bench.

B. *Approaches focusing on an expertise*

The use data collection is not enough clear if the data can't be recorded or are unavailable [14]. These approaches aim to provide judgment about the interface ergonomic quality. This approach complements empirical approaches to ensure that a maximum of criteria are inspected. It will also be required if it is impossible to involve system users and potential users [16]. It is an empirical approach and it includes 3 sub categories:

1) *Human Expertise*

This technique aims to assess the ergonomic quality of the interface by a specialist in human-machine communication and propose improvements. This technique is simple to implement and inexpensive. However, it requires more than an expert to ensure a good HCI evaluation.

2) *The workload estimation*

This method predicts HCI aspects facilitating the resolution of problems encountered by the user, and the learning process [14].

3) *The test design with users*

The evaluation grid allows evaluating the interface according to several ergonomic criteria.

C. *Approaches focusing on HCI modeling*

There are analytical approaches they are considered when interface does not exist. There are based on formal models of the interface and the progressive implementation of objective metrics. They are used to predict through specification aspects related to the HCI. These approaches are divided into two categories; the Predictive Formal models and the Quality HCI software approaches formal models

An overview of assessment methods and techniques was presented. Some methods are address experts, while others are directed toward users. In this paper, we are interested to enhance the questionnaire technique, which is a subjective assessment tool, in order to help evaluators to improve the quality of the HCI of the interactive system in the industrial field.

Considering that usability is one of the major factors that determine the successfulness of a system, we give a study of the necessary usability aspects needed to evaluate an interactive system and to design an efficient web questionnaire tool in the next section

IV. USABILITY ASPECTS USED TO DESIGN AN EFFICIENT WEB QUESTIONNAIRE TOOL

Usability is a core term in Human-Computer Interaction (HCI) [20]. In the literature, different ways can be found on

defining and explaining what the usability term means, among them we quote the definition cited by Riekkilä et al [21]: "Usability is the efficiency of how the user can reach her goals using the application and associated technology"

As defined by ISO 9241-11, usability is "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" [22].

The development of a reliable questionnaire that can retrieve useful information for the evaluation of interactive systems is a not trivial task. This task is partially very sensitive in the sense that it must cover a maximum of points relating to the quality of the evaluated interface. It is based on the choice of the factor to inspect and the evaluation aspects which must include the different criteria for evaluating the HCI quality and the interactive system. Indeed, it must be preceded by a comprehensive study of the various assessment aspects.

To assess the usability factor, these aspects should be based not only on the information related to the system functioning but also to the ergonomics aspects of the interface [23] [24]. To evaluate the usability of an interactive system, it is very important to determine the appropriate criteria relating to each aspect.

According to Senach" The criterion of usability reflects the quality of the HMI in terms of ease of learning and use, as well as the quality of the documentation" [11].

Indeed, this dimension focuses on several factors that vary from one author to another. According to Arban [25], usability focuses on the following criteria: execution time, the user satisfaction, ease of learning, ease of ownership, effectiveness or efficiency. According to Robert [26], the usability concerns consistency, visual clarity, flexibility and control, compatibility, feedback, quality of online help documentation, error handling, etc. According to ISO 9241 [22], the criteria of usability can be summarized as follows: effectiveness, efficiency, user satisfaction, ease of learning, ease of ownership, ease of use and reliability.

In addition to these usability criteria, many ergonomic evaluation criteria have been implemented [17]; [27]; [28]. There are directly addressed to evaluating the ergonomic of interactive systems. The ergonomics assessment is a necessary and complementary task to evaluate an interactive system. Ergonomic criteria have guides for evaluating the ergonomic quality of the Human Machine Interface of the interactive system and avoid the pitfalls of the subjectivity by providing users with a neutral and efficient framework. However, the choice between these criteria depends on the evaluated.

In the next section, we define our proposed web generation questionnaire environment.

V. PROPOSED WEB GENERATION QUESTIONNAIRE ENVIRONMENT TO PROVIDE A SUBJECTIVE EVALUATION FOR THE INTERACTIVE SYSTEM INTERFACE

In this paper, our goal focuses on improving the subjective evaluation of the Human-computer Interface quality of the interactive systems using a questionnaire tool. In order to aid evaluators to assess any interactive system we are interested to design a web questionnaire generation tool. The preparation of this tool requires a specification phase which defines the followed evaluation process. This process should be automated to provide best results. That's why we are interested to suggest a new environment of a web generation questionnaire system which includes an automated evaluation process. The ISO standards have supplied great importance to the quality evaluation topic by defining standardized evaluation process. The ISO/IEC 14598 series of standards give methods for measurement, assessment and evaluation of software product quality [2]. In this section, we are interested to propose an evaluation environment of a Human-Computer Interface using a questionnaire tool which includes an automated subjective evaluation process based on ISO 14598[2] norms and by exploiting the assessment process inspired by [29]. This later is based on three main steps: the preparation of the evaluation, the evaluation itself and the monitoring of evaluation.

A. The evaluation process-ISO/IEC 14598-5

The ISO/IEC 14598 [2] is an International Standard. It was prepared by Joint Technical Committee (JTC) ISO (the International Organisation for Standardisation) and IEC (the International Electrotechnical Commission), Information Technology- Evaluation of software product. It focuses on the evaluation process of an explicit way. The originality of this standard lies in structuring the evaluation process, presented in Table 2.

TABLE II. OPERATION OF AN EVALUATION(INSPIRED BY ISO/IEC 14598)[30]

Operation of an evaluation(inspired by ISO/IEC 14598)	
Step	Action
1	Establish: - Requirements - Requester responsibilities - Evaluator responsibilities
2	Analyze evaluation requirements
3	Specify the evaluation
4	Designing the evaluation
5	Execute the evaluation
6	Conclude the evaluation

This standard consists of several assessments parts which provide guidance and requirements for the evaluation

process (ISO/IEC 14598-1, 2, 3, 4, 5, 6). It is based on the assessment sponsor needs (buyers, developers and evaluators).

As illustrated in figure 1 the ISO /IEC 14598-5 evaluation process comprises five activities:

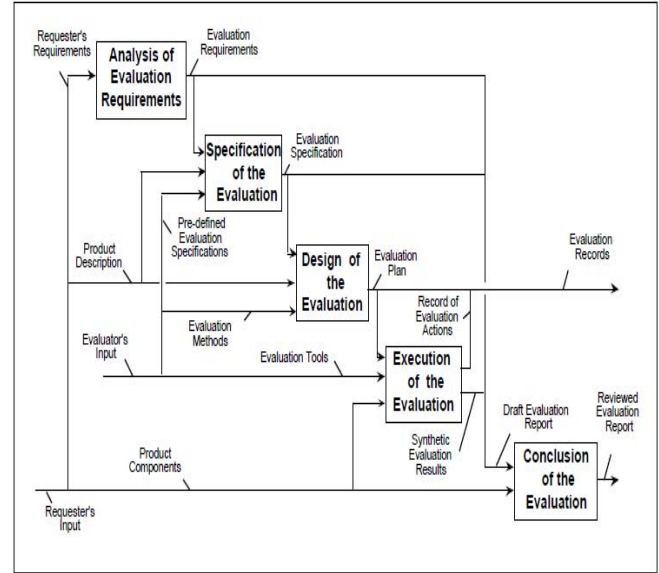


Figure 1. The evaluation process- ISO/IEC 14598-5 [2]

- Analysis of evaluation requirements
- Specification of the evaluation based on the evaluation requirements and on the description of the product provided by the requester [2]
- Design of the evaluation which produces an evaluation plan on the basis of the evaluation specification[2]
- Execution of the evaluation plan which consists of inspecting, modelling, measuring and testing the products and its components according to the evaluation plan; the actions performed by the evaluator are recorded and the results obtained are put in a draft evaluation report [2]
- Conclusion of the evaluation, which consists of the delivery of the evaluation report and the disposal by the evaluator of the product evaluated as well as its components when they have been transmitted independently[2].

B. Proposed web generation questionnaire environment

Figure 2 illustrated our proposed web generation questionnaire system environment which includes our proposed subjective evaluation process based on ISO 14598-5 norm. It includes three main modules with a SQL database which contains the system data (questionnaires, questions, users' responses, results...).

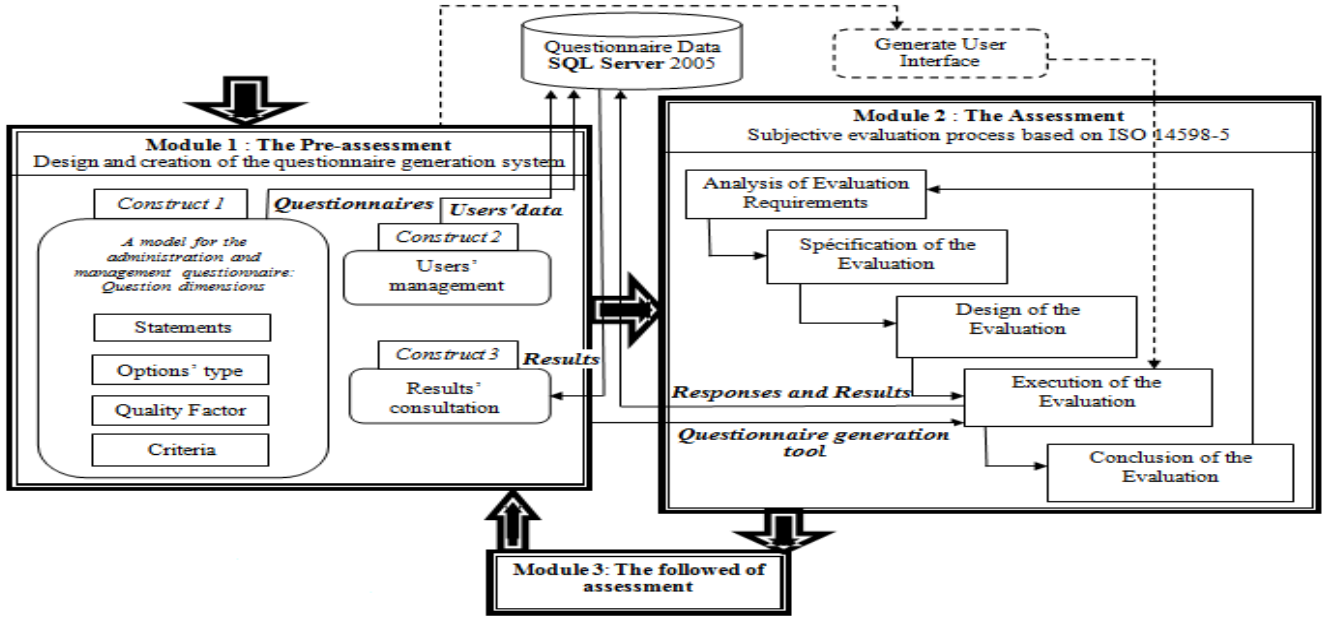


Figure 2. Proposed web generation questionnaire environment

As showed in figure 2, our proposed environment involves also three modules starting with the preparation of the evaluation, the evaluation itself to the monitoring of evaluation.

1) *Module 1: The Pre-assessment*

Pre-assessment is a primordial step. In fact, it is related to the choice of the evaluation method such as questionnaire tool, interview ...

As we have explained before, our choice is fixed to the questionnaire tool.

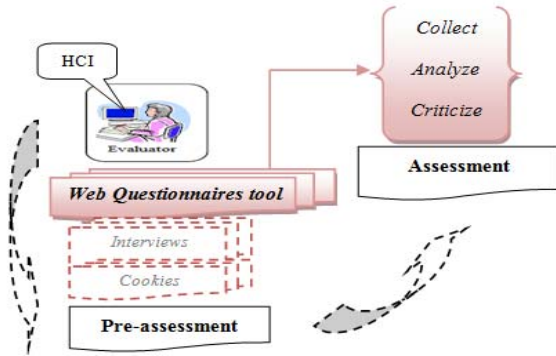


Figure 3. The evaluation tool: The questionnaire

As we have shown in the related works section, there are various standardized web questionnaires, such as SUMI [5]. There are able to evaluate the usability quality factor of the Human-Computer Interface. These proposed questionnaires are based on a standardized norms and include a set of a defined questions which can measure the evaluation criteria such as the ergonomic criteria.

We propose a questionnaire model which defines the questionnaires applied structure. This model is able to provide the evaluator the possibility to choose the factor to inspect (usability, utility , accessibility) and the evaluated criterion in order to respond to evaluators requirements. As illustrated in figure 3, our proposed model involves three main constructs: the questions management, users' management and the results consultation.

a) *The questions management:*

Designing a Model of HCI evaluation questionnaire is a not trivial task. There are some points to consider when creating and formulating questions dedicated to evaluate a Human computer Interface: the statement, the question nature, options, the quality factor and the evaluation criteria. In fact, evaluators should ask clear and precise questions and should not be ambiguous. Also questions should be adapted to each context assessment. In general there are three questions types: open questions, closed questions and mixed questions. In our model, we are interested to choose mixed questions and closed questions with a fixed format. Moreover, it is necessary to precise the measure scale used for evaluation. The determination of the measured quality factors is crucial such as usability, utility, sustainability, accessibility... These factors should be associated to a set of evaluation criteria which can be composed of sub criteria. Figure 4 illustrated the proposed questionnaires and questions model.

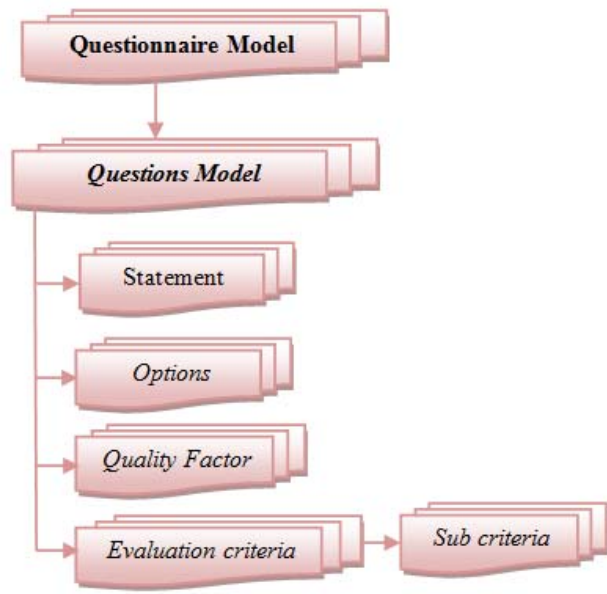


Figure 4. The proposed questionnaires and questions model

b) Users' management:

Our model is comprised of two interfaces: the administrator interface and the users interface. As an administrator, an evaluator can manage the users' list. That's why, it provides these following spots: add users, consult the users' list, and remove users.

For confidentiality reasons, an evaluator does not have the right to know the users passwords.

c) Results' consultation:

It is a crucial component in our proposed model. It presents the recording area of the evaluation results. Furthermore, it allows the evaluators of the interactive systems to consult the obtained results due to an automatic processing of the users replies during the evaluation phase. This processing will be dealt in the following section.

2) Module 2: The Assessment

Quality evaluation includes various activities, since the specification of evaluation objectives, to repair the interface defects, through the implementation of the chosen method [30].

The figure 5 gives an overview of our proposed automated subjective evaluation process using the questionnaire tool. The automatization consists in the execution phase by automating these three actions: collecting, analyzing and criticizing.

As illustrated in figure bellow, the assessment module contains five steps starting by the analysis of evaluation requirements until finalization of the evaluation.

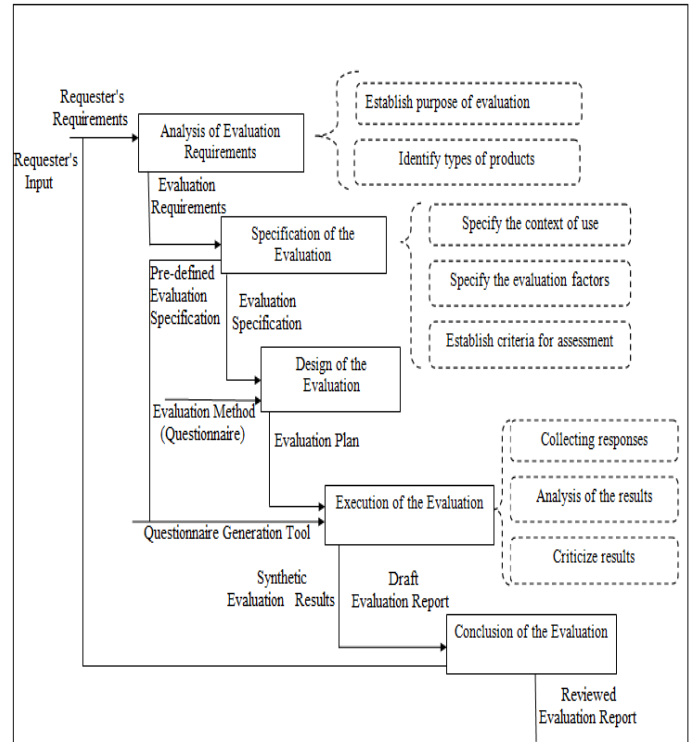


Figure 5. The proposed subjective evaluation process based on ISO 14598-5 norm [inspired by ISO 14598]

a) Analysis of evaluation requirements:

This is the selection of parts of the ISO quality models that are relevant to a particular context of quality assessment. Based on the ISO 14598-5 norm, this sub-process contains two activities, namely: Establish purpose of evaluation and identify types of products. The evaluation requirements shall consist of a list of quality requirements referring to quality characteristics [2]

In this step, we are interested to:

- Identify goals that define what the user wants to achieve (requester's requirements)
- Identify the participants of evaluation (evaluator, developer, and requester) and the product type (the interactive system).

b) Specification of evaluation:

We focus in this step on identifying the interpretation which involves the specification of the:

- Context of use of the evaluated interactive system which includes: the choice of users (Who?), the platform to use (WIMP², WUI³, Mobile UI, etc) and the physical work environment (specifying the evaluated interactive system) and the context assessment.
- Evaluation factors (the quality factors) and their associated criteria according to the evaluation

² Windows, Icons, Menus, Pointer

³ Web, User, Interface

requirements defined in the first step. These factors must be carefully adapted according to the context.

- Furthermore, the definition of the evaluation criteria is crucial for measuring and specifying the quality factors degree. These criteria are often established implicitly so that they can be determined at the execution phase.

c) Design of the evaluation:

It is the identification phase of the evaluation plan. The evaluation plan describes operational procedures needed to implement the evaluation specification [2]. This plan will be inspired by the ISO/IEC 14598-2 documentation.

d) Execution of the evaluation (Conducting):

The execution phase is a crucial step. It can be consider as the heart of the web generation questionnaire system. It is the implementation phase. It includes four sub-phases that there will be running inside the questionnaire tool:

- The launch of the application
- The collection of responses which will be performed automatically once users confirm their answers when running our application: and
- The analysis of the results which also will be performed automatically.
- The critical phase: it presents the generation phase of evaluation reports used the Crystal report tool.

e) Conclusion of the evaluation:

It presents the communication phase of the final report in which the evaluator is responsible to check the evaluation report based on the detected usability problems.

3) Module 3: The followed of assessment

Upon receiving the reviewed evaluation report of the interactive system, designers are able to make the necessary improvements in the human-machine interface based on the evaluation report which will be automatically generated by our tool.

The questionnaire results will be combined with the results of the others tool such as the cookies to generate a synthesis of the various results for the evaluation of Interactive Systems.

VI. CONCLUSION AND PERSPECTIVES

The quality evaluation has been well exploited in the field of Human Computer Interaction. Whatever the development methodology applied, it is very crucial to assess the quality of the application.

In this paper we are interested to define the proposed environment to design a web questionnaire generation tool in order to aid for interactive systems quality subjective assessment. This environment contains the proposed model and the automated subjective evaluation process applied based on the ISO 14598-5 norm. We have already implemented the first version of the web generation questionnaire tool. The obtained results will be soon reported.

As a part of our future work, we intend to enhance the execution step and particularly the analysis phase by

selecting and implementing an analysis method to support decision.

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