Studying and Analyzing the Evaluation Dimensions of E-learning Platforms Relying on a Software Engineering Approach

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Abstract—We are currently witnessing the launch and development of a large number of distance training devices in Moroccan universities, whose main objective is to meet society's requirements and the knowledge economy, which is fully emerging. All of the devices are based on the use of e-learning platforms, which can be problematic for designers for different reasons (costs, utility, usability, etc.). Being conscious of the impact of these technological tools on learning, we propose a methodical approach that identifies the essential criteria for evaluation of e-learning platforms to fit the needs of teachers and learners from analysis of the evaluation dimensions in multimedia documents, particularly through the dimensions of utility and usability.

Index Terms—e-learning platforms evaluation, evaluation approach, evaluation process, e-learning platform, software engineering, software engineering approach.

I. INTRODUCTION

One of the essential features of knowledge economy is the acceleration of interactive software life cycles, which are part of e-learning platforms. The choice of these platforms, which constitute the cornerstone of initial and continuing training systems, is not obvious to most users. But why is this so difficult?

As part of our study, we will show that choosing between the various tools available on the market forced us to identify the challenges and the specific needs. It was crucial to ensure these tools would provide rich services motivated by the online sharing of structured information and interactivity among different users. To this, we added the tracking services of the learning paths of different users, notably learners.

It was obvious that the use of any tool in the field of education and training had to be justified according to its pedagogical interest and its response to the needs of the learners, but if the platform is supposed to address the spatial and temporal constraints between tutors and learners, it must not hinder the learning process.

Consequently, any random choice that entails a loss of money, effort and time challenges us and invites us to ask the following questioning:

On the one hand, how can we choose an e-learning platform that meets the norms and standards as they are acknowledged in distance education devices?

On the other hand, e-learning platforms are objects of evaluation, so to what degree of training specificity can they respond? What are the choices in terms of multimedia engineering on which we must analyze these platforms? What norms and standards do the requirements meet in evaluation of these platforms?

These issues and others are the subject of the investigations as part of our approach to judge its intake for experimentation purposes.

For our study, reading of the specialized literature in the e-learning platforms analysis shows two orientations. The first is dedicated to the technical analysis (computer language, script, metadata), and the second covers the pedagogical extent of these platforms and the development of the learners' skills.

Our approach is oriented toward a reconciliation of these two orientations. The technological and pedagogical are not mutually exclusive; however, crossing their elements in a goal or technology is at the pedagogical center.

To concretize our approach, in the "theoretical frame" section, we initially took the evaluation dimensions of interactive systems conducted by Senach [3], Tricot [4] and ISO 25010 [18]. Then we categorized these works and the various discussions [1, 2]. After analysis, we retained the dimensions of utility and usability.

Then, in the "analysis of assessment dimensions" section, we followed a specific methodology for analyzing the evaluation dimensions obtained according to the three steps indicated:

- Comparison of studied outcomes,
- Personal position relative to the outcomes,
- Analysis and results (choose criteria and tools suitable for evaluation of the platforms).

This section mainly consists of three sub-sections:

1. Utility analysis: In this sub-section, we will categorize the utility characteristics discussed, according to various studies [3, 4, 18, 20]. After the analysis, we retained six utility characteristics. Thereafter, we attempted to subject the tools of currently recognized e-learning platforms to filter the criteria that met the pedagogical principles of training, based on various studies [6, 7], to check the quality and the presence of the tools available to the various players in distance training. Then we checked their utility and their operability through interactive technologies that met the retained characteristics [18].

2. Usability analysis: In this sub-section, we categorize the most important usability criteria, according to various studies [11, 9, 17, 22, 5, 20, 16, 4, 21, 8, 12, 13, 24, 23, 18, 10]. After the analysis, we selected eight usability criteria to be part of our evaluation gait.

3. Evaluation approach of platforms: In this sub-section we present the measures and criteria adapted for the evaluation of e-learning platforms according to a scalable approach and synthesis of the two analyzed dimensions.

II. E-LEARNING PLATFORM

A. Definition

As we defined OVAREP [6], the e-learning platform is a computing device that groups several tools and ensures the educational conduits. Across dedicated platforms to the ODL[3], all conduits are preserved and expanded for the learner, tutor, administrator, etc. within the e-learning platform.

Thereby, the tools offered by these platforms enable tutors and learners to communicate individually or collectively and discuss themes and shared documents.

The learner is invited to consult on the course, to realize the homework, to follow its development, and to receive self-generated feedback or feedback given by the tutor. In this environment, the learner exchanges his knowledge, his remarks and contributions (production or document) with other learners to self-evaluate and transmit his work to a teacher, whether it is individually or collectively.

A training coordinator is responsible for the learners' inscription management, of the time, and of the rhythms of the formation and activity of the teaching team.

The teacher (course designer) is responsible for the preparation of courses and tutors. The tutor is supposed to bring the necessary support to the learners at both cognitive and methodological levels. The tutor's role differs according to the pedagogical presuppositions inherent to the e-learning platforms.

He can be an animator in a collaborative educational device, facilitator in a constructivist educational device, organizer of learning situations conducive to dialogue with a view to cause and resolve conflicts in a social-constructionist educational device; presenter of information via a structured, hierarchical, and deductive in a cognitivist educational device; or an expert on a transmissive educational device.

The administrator plays a technical role and cannot be confused with the role of the coordinator who has as a function in the following tasks:

• Installs and maintains the system,

• Manages access and rights,

• Creates links with external information systems (school, catalog, teaching resources, etc.).

B. Platform features

An e-learning platform exists to bring answers to the following problems:

• Expand the training offered through the ODL and allow those who find training constraints to have opportunities to overcome them,

• Access to the best management of time jobs by reducing the supply in presential training,

• Develop exchange, inter-actors of training,

• Innovate the teaching practices by using new technologies for communication and training,

• Introduce other modalities of training such as management of collaborative projects,

• Foster the role of tutoring that allows reducing the sensation of isolation, often the cause of stalling and abandonment.

An e-learning platform fits well in several pedagogical models. We defined our expectations in matters of content and teaching modalities for all the actors: learners, integrators, tutors, coordinators and administrators.

Learners are invited to

• Attend pedagogical activities that take various forms, both specific and general (problems, simulations, QCM, tests self-correcting),

• Include interactive teaching resources in various formats (text, image, audio, video, PDF, Flash),

• Realize situations for assessments,

• Access collaborative working from shared documents.

The learning path is divided into two entities:

• Entity 1 consists of creating modules that are broken into several units that contain various resources (documents, activities, quiz) and learning path-oriented supports (individual or a group),

• Entity 2 consists of achieving a set of activities (in relation to the objective of the module) as part of project-based teaching, courses oriented activities.

Teachers (course designers) are responsible for the preparation of training courses with regard to

• Creation of the teaching resources interface with the training management systems (AICC, SCORM, etc.),

• Sharing educational resources (course modules, evaluations, etc.),

• Planning of pedagogical resources.

Tutors are responsible for

• Taking charge of learners by an individual tracking system, animation and / or moderation of forums,

• Initializing the conversation within the chat, which is responsible,

• Follow-up the learners in videoconference,

• Monitoring activities and proposed projects,

• Planning the interventions,

• Monitoring the groups' management.

Administrators and coordinators are responsible for customizing the platform with regard to

• Establishing the groups,

• Monitoring the activities of teachers,

• Managing the courses,

• Customizing the platform,

• Managing the roles.
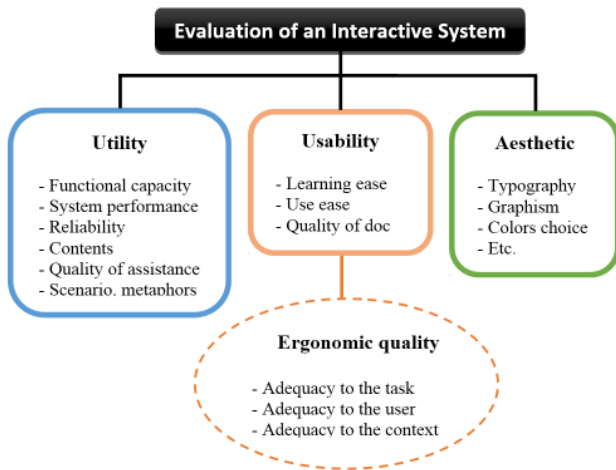
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[3] **ODL:** Open and distance learning.

Figure 1.   Dimensions of evaluation, adapted by Senach [3]

III.   THEORETICAL FRAME

E-learning platforms, like any software, must be subjected to a set of criteria that make the process of evaluation possible. These criteria are order, pedagogical, technical and ergonomic functions, etc. As part of this section, we will introduce and synthesize our theoretical foundation, taking into account the approaches of Senach [3] and Tricot [4] as well as the ISO 25010 standard [18] and the various discussions they confront [1, 2].

A.   Approach of Senach

In light of Senach's work, including "*L'évaluation Ergonomique des Interfaces Homme-Machine: Une Revue de la Littérature*" [3], we distinguished three main evaluation dimensions of interactive systems: utility, usability and aesthetics.

In a similar fashion, Figure 1 presents evaluation criteria of the three main evaluation dimensions adapted by Senach.

Regarding these three dimensions, other researchers, such as Bastien and Scapin, found that the aesthetic dimension is sometimes regarded as a component of satisfaction on the part of the user, as are the preferences of the user [1]. In addition, the aesthetic dimension is suspicious of great subjectivity and is likely to be abandoned.

B.   Approach of Tricot

Tricot added the dimension of acceptability to these three dimensions (utility, usability and aesthetics) [3]: in other words, feeling positive or negative with regard to the product, "intention" of use depending on many parameters: motivation, affects, culture, values [4]. Figure 2 presents criteria that are possible for evaluation of utility, usability and acceptability [4].

In its three dimensions, Huart found that the notions of utility and usability are often discussed in the literature [2].

In what follows, the ISO 25010 standard completes what has been developed by different studies and presents a model of the quality of interactive systems of the eight characteristics.

C.   Approach of ISO 25010 standard

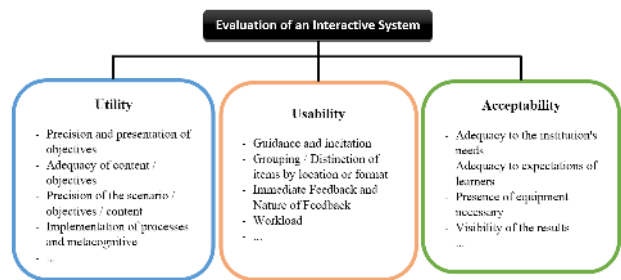In the quality model of interactive systems, the most famous characteristics are those of the ISO / IEC 9126-1:

Figure 2.   Presentation of measures and criteria for evaluation by inspection of a HSI[4] [4]

TABLE I.
QUALITY MODEL INTERACTIVE SYSTEMS OF ISO 25010 [18]

Characteristic	Sub Characteristic
Functional suitability	Functional completeness
	Functional correctness
	Functional appropriateness
Performance efficiency	Time behavior
	Resource utilization
	Capacity
Compatibility	Co-existence
	Interoperability
Usability	Appropriateness recognizability
	Learnability
	Operability
	User error protection
	User interface aesthetics
	Accessibility
Reliability	Maturity
	Availability
	Fault tolerance
	Recoverability
Security	Confidentiality
	Integrity
	Non-repudiation
	Accountability
	Authenticity
Maintainability	Modularity
	Reusability
	Analysability
	Modifiability
	Testability
Portability	Adaptability
	Installability
	Replaceability

2001 [20]. These characteristics, were originally developed in 2001 and revised in 2011 by the ISO / IEC 25010: 2011 [18], which incorporates the same software quality characteristics with some modifications.

The quality model of interactive systems of ISO 25010 standard consists of eight characteristics: functional suitability, performance efficiency, compatibility, usability, reliability, security, maintainability, and portability. Each characteristic is composed of a set of related sub-characteristics.

Table I presents a quality model interactive system of the eight main evaluation characteristics of the ISO 25010 standard.

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[4] **HSI**: Human-computer Interaction

IV. SPECIFICITIES ANALYSIS OF PLATFORMS

In the project, we followed a detailed evaluation strategy of the platform's evaluation criteria while referring to two retained evaluation dimensions.

A. Utility analysis

In the development of interactive software, the most popular utility criteria were presented in the "theoretical frame" section. Thus, in Table II, we selected the basic criteria that constituted the cornerstone of the utility dimension, and we have them placed in comparison to users' characteristics established by different studies, depending on the possible declensions of the cited criteria.

We distinguished (see Table II) that the functional ability is often recommended in most studies. For this, we retained this characteristic because it is often the subject of interactive systems evaluation.

In 1990, Senach treated the functional capacity. Then, in 2001, ISO 9126-1 standard completed what Senach started and nicknamed this characteristic "functionality," which consists of sub-related characteristics in particular: compatibility/interoperability and security.

In addition, in 2011, the ISO 25010 standard reviewed what had been originally developed by ISO 9126-1 and incorporated the same software quality characteristics with some changes. Among these changes, we found that this standard gave more importance to compatibility and security, which originally were the sub-characteristics of the functionality characteristic of ISO 9126-1 standard, nicknamed "functional suitability."

Thereby, we also retained compatibility and security. Moreover, we added the characteristic of portability because it is practically discussed (see Table II), and it gives more importance to the adaptability of the platforms for mobile devices because it facilitates distance learning.

We, therefore, selected four criteria of utility, namely:

- Functional suitability,
- Compatibility,
- Security,
- Portability.

Subsequently, we used these retained criteria, in comparison to users' characteristics established by different studies, based on Table III. After analysis, we found that the four criteria of usefulness address the characteristics of ISO 25010 because they are often recommended in most studies.

Usually, the ISO 25010 consists of eight related characteristics; however, in this dimension, we treated just six characteristics of this standard: functional suitability, performance efficiency, compatibility, security, maintainability and portability. These characteristics, in our view, are best suited to assessing the usefulness of the e-learning platforms.

Thus, the two other characteristics of ISO 25010: usability and reliability will be treated in the usability dimension.

In what follows, we used the currently recognized functionality tools of e-learning platforms to filter the criteria that meet the six characteristics of utility.

TABLE II.
COMPARISON OF CHARACTERISTICS USERS IN THE DESIGN INTERFACE OF UTILITY

Utility Criteria / Categories	Functional Capacity	Maintainability	Compatibility / Interoperability	Compatibility / Co-existence	System Performance	Security	Assistance Quality	Portability	Contents	Scenario
Senach (1990)	x				x		x		x	x
ISO 9126-1 (2001)	x	x	x			x		x		
Tricot (2003)									x	x
ISO 25010 (2011)	x	x	x	x	x	x		x		

1) Analysis of functionality tools

Based on Ahmed Lablidi's Table and OVAREP's study [6] as well as Aska's Table and Anne Bouthry's study [7], after analysis, we tried to adapt these criteria to the specific needs of our approach. Thus, a set of functionalities were identified for each actor of the platform to perform his task. Among these IT functionalities, we are providing actors tools of communication, monitoring, sharing, security, interoperability and organization, etc. Table III associates the criteria to the given tools at disposition for each actor.

Five actors were distinguished:

- Learners,
- Teachers (course creators), responsible for the preparation of tutors and training courses,
- Tutor, responsible for monitoring learners,
- Coordinator, responsible for the platform integration into the overall operations of the tutors establishment,
- And administrator, responsible for customizing the platform.

For each actor, we analyzed the breadth of functionalities to which he has access, integration of these functionalities, ease of use, and requirements with regard to competence.

Conscious that platforms are not generic to evaluate adequacy between technological tools and pedagogical intakes for the different actors, we evaluated the ease of editing courses, the process of monitoring and coaching, and the interactive aspects among users of the platform.

We know that the mission of a platform is made available to users through the pedagogical activities. Thus, the functionalities offered would first help the different actors fulfill their respective tasks and enable cooperation and communication among the users.

Our analytical work advocated determining the functionalities by using a checklist (see Table III) and then checking their utilities and categorical location, according to a method of analysis by characteristic.

TABLE III.
SELECTED CRITERIA AND TOOLS FOR CHOOSING AN E-LEARNING PLATFORM

Actors	Criteria	Tools
Learner	Synchronous communication	Chat, virtual classroom (videoconferencing / webinar)
	Asynchronous communication	Forum, messaging, mailing
	Document Sharing	Deposit space of document, virtual library, database, forum, Wiki, Dropbox, Shared folders
	Historical of documents	Social networks, forum
	Organization	Calendar, Post-it, dashboard
	Evaluation	Tests, dashboard , portfolio, quiz
	Collaboration	Wiki, dlassroom (videoconferencing / webinar), portfolio, forum
	Plagiarism Detection	Plagiarism detection tools
	Certification	Followed certificate of training
Teacher, tutor	Registration of learners	Calendar, dashboard
	Groups management	Registration to one or more groups, calendar, dashboard
	Tracking of learners	Tracking, number of times that the learner has logged in, the connections dates, executed activities (courses, discussions, forums, tests, etc.), % success, progress monitoring
	Management of tests	Generator of QUIZ and test, self-evaluation tests, managing notes: average calculation, displaying notes, report on the test results
Administrator, coordinators	Assignment of courses to learners and tutors	Data processing by group and tutors
	Dissemination of results	Import and export formats supported by different file types
	Management of user roles	Multi-profile management (learners, teacher, tutor, integrator / author)
	Course transfer from one platform to another	Example: transfer of a course on Moodle platform to Claroline platform
	Customizing the platform	Managing roles, groups, modules, access rights, etc.
Teacher, course designer	Multimedia content	Audio, video, flash, etc.
	Resource Management	Filing space of documents
	IMS interoperability standards	SCORM, IMS QTI, AICC, IMS XML
	Support of multiple authors	The right to create, manage its own course, and give the right of access to another teacher
	Import and export	Import and export of the tests
All actors	Presence of other actors	Awareness
	Identification	Visit card, profile, badge and dashboard.
	Security	Possibility to use SSL, security by login / password, Assigning username and password, security barrier, backup system.
	Compatibility with common browsers	Compatibility with common browsers such as: Firefox, Chrome, Opera, etc.
	File diffusion means	RSS
	Used technology	PHP, JAVA, ASP, PITON, etc.
	Used Database	SQL, NoSQL
	Interaction with other operating systems	Unix, Linux, Mac OS X, Microsoft Windows, FreeBSD, etc.
	Interaction with other databases	PostgreSQL, SQLite, MS SQL, MySQL, Oracle DB, MariaDB, Percona, etc.
	Possibility of using plugins	Such as PDF, Excel, PowerPoint, Word, etc.
	Portability	Adaptation to mobile terminals
	Adapting to different training devices	Creating MOOC or SPOC

We usually distinguished six characteristics previously retained:

- Functional suitability,
- Performance efficiency,
- Compatibility,
- Security,
- Maintainability,
- Portability.

For each of the characteristics and its sub-characteristics, we analyzed the functionality with which it has access and the integration of these characteristics to available tools for each characteristic based on the criteria and selected tools in Table III.

In the following, the six essential characteristics were retained to conduct distance training with functionality tools to meet the previously outlined criteria (see Table III).

2)   Functional suitability

Functional suitability means "the degree to which a product or system provides functions that meet stated and implied needs when used under specified conditions" [18].

Table IV projects the essential functionalities for functional suitability and the sub-characteristics meeting the previously outlined criteria. Three sub-characteristics related to functional suitability were distinguished and defined in accordance with ISO 25010:

- Functional completeness: "the degree to which the set of functions covers all the specified tasks and user objectives"
- Functional correctness: "the degree to which a product or system provides the correct results with the needed degree of precision"
- Functional appropriateness: "the degree to which the functions facilitate the accomplishment of specified tasks and objectives"

TABLE IV.
FUNCTIONAL SUITABILITY TOOLS ADAPTED FOR CHOOSING AN E-LEARNING PLATFORM

Functional suitability	YES	NO
Functional completeness		
Forum		
Synchronous causerie (cat / chat)		
Virtual Classroom (videoconferencing / webinar)		
Sharing documents		
Calendar		
Awareness (list of connected people)		
Tests management		
Collaboration (Wiki)		
Learners' management (registration, schedule...)		
Learners management in working groups		
Users roles management		
Customizable platform		
Advancement Scale or progression percentage in the course		
Resource Management (course)		
Support of multiple authors		
Functional correctness		
Management of working time of learners and Teachers		
Results and notes		
Notes display		
Tracking statistics of course		
Control Connections (tracking of learners)		
Report on the test results		
Glossary		
Report on the frequency or the use of a course		
Functional appropriateness		
Certification (certificate of training follow-up)		
Foyer (family group)		
Registration chat		
Messaging		
Plagiarism detection tools		
RSS / podcast : means of distributing files (audio, video or other)		

TABLE V.
PERFORMANCE EFFICIENCY TOOLS ADAPTED FOR CHOOSING AN E-LEARNING PLATFORM

Performance efficiency	YES	NO
Resource utilization		
Is that platform functionalities tools meet the distance requirements Learning		
Capacity		
Is that the platform meets all the distance requirements learning		
Assistance quality		

3) Performance efficiency

Performance efficiency means "the performance relative to the amount of resources used under stated conditions" [18].

In Table V, we project the essential functionalities for performance efficiency and the sub-characteristics meeting previously outlined criteria. Two sub-characteristics related to performance efficiency were distinguished and defined in accordance with ISO 25010:

- Resource utilization: "degree to which the amounts and types of resources used by a product or system, when performing its functions, meet requirements"
- Capacity: "degree to which the maximum limits of a product or system parameter meet requirements"

4) Compatibility

Compatibility signifies "the degree to which a product, system or component can exchange information with other products, systems or components, and/or perform its required functions, while sharing the same hardware or software environment" [18].

Table VI presents the essential functionalities for compatibility and the sub-characteristics meeting the previously outlined criteria. Two sub-characteristics related to compatibility were distinguished and defined:

- Co-existence: "degree to which a product can perform its required functions efficiently while sharing a common environment and resources with other products, without detrimental impact on any other product"
- Interoperability: "degree to which two or more systems, products or components can exchange information and use the information that has been exchanged"

5) Security

Security means "the degree to which a product or system protects information and data so persons or other products or systems have the degree of data access appropriate to their types and levels of authorization" [18].

TABLE VI.
COMPATIBILITY TOOLS ADAPTED FOR CHOOSING AN E-LEARNING PLATFORM

Compatibility	YES	NO
Co-existence		
Course transfer from one platform to another of the same type		
SCORM (allows creating grains of course, reusable and interoperable).		
IMS QTI (set of specifications allowing interoperability to test systems)		
AICC (sets the interoperability between the platform and content)		
IMS XML		
Interoperability		
Information and application sharing		
Import and export of resources		
Possibility of using plugins (Word, Excel, etc.)		
Technology used (PHP, J2EE, ASP…)		

Table VII shows the essential functionalities for security and their sub-characteristics meeting the previously outlined criteria. Five sub-characteristics related to security were distinguished and defined in accordance with ISO 25010:

- Confidentiality: "degree to which a product or system ensures that data are accessible only to those authorized to have access"

- Integrity: "degree to which a system, product or component prevents unauthorized access to, or modification of, computer programs or data"

- Non-repudiation: "degree to which actions or events can be proven to have taken place, so that the events or actions cannot be repudiated later"

- Accountability: "degree to which the actions of an entity can be traced uniquely to the entity"

- Authenticity: "degree to which the identity of a subject or resource can be proved to be the one claimed."

6) Maintainability

Maintainability means "the degree of effectiveness and efficiency with which a product or system can be modified by the intended maintainers" [18].

In Table VIII, the essential functionalities for maintainability and for their sub-characteristics meeting the previously outlined criteria. Five sub-characteristics related to maintainability were distinguished and defined in accordance with ISO 25010:

- Modularity: "the degree to which a system or computer program is composed of discrete components such that a change to one component has minimal impact on other components"

- Reusability: "the degree to which an asset can be used in more than one system, or in building other assets"

- Modifiability: "the degree to which a product or system can be effectively and efficiently modified without introducing defects or degrading existing product quality"

- Testability: "the degree of effectiveness and efficiency with which test criteria can be established for a system, product or component and tests can be performed to determine whether those criteria have been met"

7) Portability

Portability signifies "the degree of effectiveness and efficiency with which a system, product or component can be transferred from one hardware, software or other operational or usage environment to another" [18].

Table IX shows the essential functionalities for portability and for their sub-characteristics meeting the previously outlined criteria. Three sub-characteristics related to portability were distinguished and defined in accordance with ISO 25010:

- Adaptability: "degree to which a product or system can effectively and efficiently be adapted for different or evolving hardware, software or other operational or usage environments"

TABLE VII.
SECURITY TOOLS ADAPTED FOR CHOOSING AN E-LEARNING PLATFORM

Security	YES	NO
Confidentiality		
Secured by login / password		
Assigning access rights		
Integrity		
Ability to use SSL		
Non-repudiation		
Tracking system		
Backup system		
Accountability		
Barrier of security		
Authenticity		
Assigning username and password		
Identity card (visit card / profile)		

TABLE VIII.
MAINTAINABILITY TOOLS ADAPTED FOR CHOOSING AN E-LEARNING PLATFORM

Maintainability	YES	NO
Modularity		
Is that the platform contains of discrete plugins		
Reusability		
Interaction with other operating systems (multi-operating systems option)		
Interaction with other databases (multi-database option)		
Modifiability		
Modifiability of the system without errors		
Testability		
Maintenance and updating		

TABLE IX.
PORTABILITY TOOLS ADAPTED FOR CHOOSING AN E-LEARNING PLATFORM

Portability	YES	NO
Adaptability		
Adaptation to mobiles terminals		
Compatibility with common browsers		
Adapting to different training devices (creating MOOC or SPOC)		
Installability		
Instability of without errors platform		
Replaceability		
Replaceability with the new platform version		

- Installability: "degree of effectiveness and efficiency with which a product or system can be successfully installed and/or uninstalled in a specified environment"

- Replaceability: "degree to which a product can replace another specified software product for the same purpose in the same environment."

B. Usability analysis

In software development and interface design, the best-known usability criteria are ones by Nielsen [9]. The "Nielsen ten usability criteria" were originally developed in 1990 and revised in 1994 after a factor analysis of 249 usability problems. Nielsen's ten principles are composed of a general list and offer broad categories.

TABLE X.
COMPARISON OF CHARACTERISTICS USERS IN THE DESIGN INTERFACE OF USABILITY

Categories	User Control	Status visibility	Errors Control	Adaptability by User	Mapping / Navigation	Simplicity	Guidance / Feedback	Guidance / Readability	Guidance / Incitation	User Language	Consistency / Coherence	Efficiency / Flexibility	Affordance	Reversibility	Working Load	Perceptibility	Aesthetic	Closing / Memory	Effectiveness / Reliability	Metaphor	Accessibility	Satisfaction
Norman (1988)		x	x		x	x	x				x			x				x				
Nielson (1995)	x	x	x				x			x	x	x		x		x	x			x		
Gerhardt-Powals (1996)		x						x			x	x			x				x			
ISO 9241-11 (1998)												x							x			x
Bastien et Scapin (2001)	x		x	x	x		x	x	x		x	x	x							x		
ISO 9126-1 (2001)		x		x		x													x		x	
Baker et al. (2002)	x	x	x			x	x	x														
Tognazzini (2003)		x	x	x	x	x		x			x	x				x				x		
Tricot et Al. (2003)	x		x	x	x		x		x		x	x	x		x					x		
ISO 10075-3 (2004)											x	x							x			
Schnederman (2005)	x		x			x					x				x			x	x			x
Stone (2005)		x			x	x					x		x								x	
Johnson (2008)	x		x			x				x	x											
ISO 9241-171 (2008)									x			x					x	x	x		x	x
ISO 9241-210 (2010)												x							x		x	x
ISO 25010 (2011)		x	x	x		x		x			x	x					x		x		x	
Tognazzini (2014)		x	x		x	x		x			x	x			x	x				x		

Other usability criteria like Bastien's eight principles [5], include Norman's seven Rules [11], Shneiderman's eight golden rules [8], Stone's eight rules [12], Johnson's eight principles [13] and Tricot's ten rules [4] as well as the standards adopted by the International Committee ISO, namely, ISO 9241-11 standard's eleven principles [22], ISO 10075-3 standard's eight characteristics [21], ISO 9241-171 standard's thirty-eight criteria [24], ISO 9241-210 standard's eighteen rules [23] and ISO 9126-1 standard's principles [20], which were developed in 2001 and revised in 2011 by ISO 25010 [18].

Tognazzini's nineteen first principles of user interface design that were originally developed in 2003 and revised in 2014 [10] largely overlap with each other. They basically redefine and reorder the same principles, as is also the case with other less known usability criteria like Aaron's [15], Gerhardt-Powals's [17], Brown's [14], and Backer's [16].

In Table X, we selected the basic criteria that constitute the cornerstones of the usability dimension and placed them in comparison with user characteristics established by different studies, depending on possible declensions of the cited criteria, to deduce the most important usability criteria for evaluation of e-learning platforms.

We selected (see Figure 3) the most affordable usability criteria identified by the different studies. The seven usability criteria recommended in most studies are

- Status visibility
- Errors control
- Consistency / Coherence
- Efficiency / Flexibility
- Simplicity
- Guidance / Feedback
- Effectiveness / Reliability

Subsequently, we put these selected criteria, in comparison with users' characteristics established by different studies, see Table X. After analysis, we found that the usability requirements of ISO 25010 standard correspond correctly with most selected criteria, except the criterion "Feedback." However, "Feedback" has a great importance in evaluating e-learning platforms. For this, we retained the usability criteria of ISO 25010 by adding "Feedback" as part of our evaluation process.

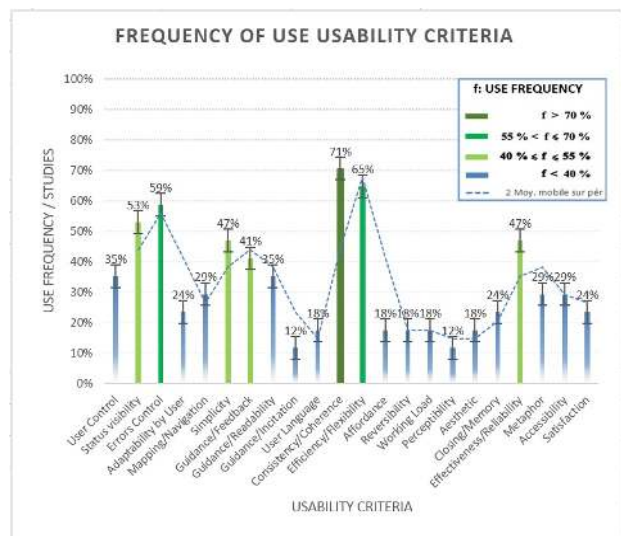In Table XI, we present the selected usability criteria.

Figure 3. Analysis of usability criteria

C. Evaluation approach of platforms

To be used effectively, all e-learning platforms need utility and usability components to be well exploited and used in the best conditions. These preconditions are known and presented in different forms. The element of requirements covers a set of specifications, such as functional suitability tools (Table IV), performance efficiency tools (Table V), compatibility tools (Table VI), security tools (Table VII), maintainability tools (Table VIII) and portability tools (Table IX) as well as the usability criteria (Table XI).

We present the evaluation approach to determine the quality of the platforms (Table XII) in an overview of the dimensions of utility and usability and the adapted criteria for evaluating the e-learning platforms.

In a similar fashion, we present Figure 4, a quality model of our main evaluation criteria of e-learning platforms, which were inspired from two dimensions: utility and usability.

V. CONCLUSION

Evaluation of e-learning platforms was the subject of an experiment. The actions of the learners and the interactions among them and with their tutors constituted a means for appreciating the achievement of the training goals.

This approach set up tags for exploration of e-learning platforms. It organized and prepared our comparative study to assess e-learning platforms and allowed us to live the experience of distance training via a suitable platform on which we built our judgment of the relevance of the teaching and technological choices and meeting most of our expectations.

In this perspective, experimentation proved essential to validate what was developed in the context of this article.

TABLE XI.   USABILITY CRITERIA RETAINED

Usability criteria	YES	NO
Appropriateness recognizability		
Learnability		
Operability		
User error protection		
User interface aesthetics		
Accessibility		
Reliability		
Guidance / Feedback		

TABLE XII.
EVALUATION APPROACH OF THE E-LEARNING PLATFORMS QUALITY

| Assessment and analysis grid of the quality of e-learning platforms |
|---|
| **Identification of the platform** |
| Platform's name: |
| Platform designer: |
| Platform type: |
| Platform genre: |
| Platform's pedagogical model:: |
| Platform license: |
| Description: |
| Version & Edition: |
| Used technology: |
| Language: |
| Website: |
| **Utility Specifications** |
| Functional suitability tools (Table 4) |
| Performance efficiency tools (Table 5) |
| Compatibility tools (Table 6) |
| Security tools (Table 7) |
| Maintainability tools (Table 8) |
| Portability tools (Table 9) |
| **Usability Specifications** |
| Usability criteria (Table 11) |
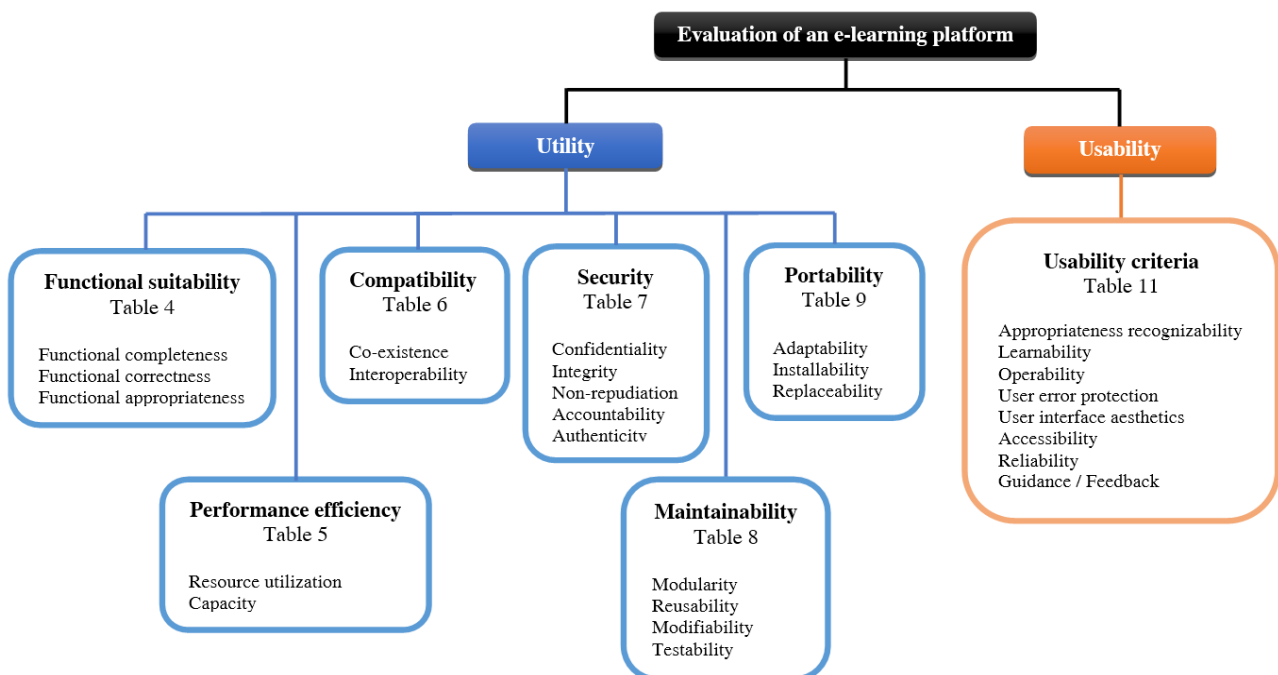
Figure 4.   Quality model selected for choosing an e-learning platform

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