SYSTEMATIC EVALUATION OF E-LEARNING SYSTEMS

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SUMMARY

The paper describes the eLSE methodology to evaluate e-learning systems. By combing a specific inspection technique with user-testing, eLSE allows inspectors, even not having a wide experience in evaluating e-learning systems, to perform accurate evaluations. The inspection technique is based on the use of evaluation patterns, called Abstract Tasks, which precisely describe the activities to be performed during inspection. For this reason, it is called AT inspection. An experiment has shown that novice evaluators are able to come out with good results, confirming the efficiency and the effectiveness of AT inspection.

KEYWORDS: e-learning system, evaluation methodology, inspection technique, controlled experiment, user study.

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1 – INTRODUCTION

E-learning is becoming very important in fields where access to learning materials needs to be brought about effectively and efficiently. Despite the large number of e-learning systems now available, one of the barriers to successful deployment of technology-based learning is the lack of high quality systems tailored to the needs of individual users and groups.

A major challenge for designers and Human-Computer Interaction (HCI) researchers is to develop software tools that can engage novice learners and support their learning. This could require revising traditional interaction paradigms to provide new flexibility and adaptiveness, suited to the peculiarities of the specific application field. Towards this end, there should be a synergy between the learning process and the learner's interaction with the software. As for any interactive system, usability is a primary requirement. If an e-learning system is not usable, the learner spend more time learning how to use the software rather than learning the contents. Thus, in this particular context, usability takes on an added dimension. Beside being usable, an e-learning system must be effective in meeting the instructor's pedagogical objectives. System evaluation should thus integrate the assessment of the educational aspects.

One of the main goals of any learning system is to avoid any distraction and to keep the whole content fresh in the learners' minds as they accommodate new and foreign concepts. In the specific case of e-learning, the challenge is to create an interactive system that doesn't confuse learners. We often find that an e-learning application is a mere electronic transposition of traditional material, presented through rigid interaction schemes and awkward interfaces. When learners complain about Web-based training or express a preference for classroom-based instruction, it's often not the training, but rather the confusing menus, unclear buttons, or illogical links that scare them off.

The user interface of an e-learning application can become a barrier to effective learning and information retention: if it is not well designed, the user can feel lost, confused or frustrated (Kruse, 2000). Moreover, technology should not become a barrier. Users with different hardware and software equipment should be able to exploit the e-learning artefacts, possibly through suitably customized access procedures.

Squires and Preece argue that researchers have so far not given enough importance to the implications of the usability features of an educational application when trying to achieve educational goals (Squires and Preece, 1999). To this end, the authors assert that "*there is a need to help evaluators consider the way in which usability and learning interact*".

In literature, the number of studies devoted to identifying usability issues of e-learning systems is small and not proportionate to the importance of e-learning. Moreover, the proposed criteria are often only vaguely stated, so that any actual measurement is left to subjective interpretation. Some authors have proposed that the usability heuristics summarized by Nielsen (Nielsen, 1993) and Shneiderman (Shneiderman and Plaisant, 2004) can be applied to evaluate e-learning applications interfaces (Schwier and Misanchunk, 1993; Dringus, 1995). Other researchers assert that usability testing needs additional consideration in the light of the e-learning environments currently available, and propose a list of heuristics adapted to such a context (Quinn et al., 1997; Squires and Preece, 1999; Notess, 2001).

For the above reasons, the evaluation of e-learning systems deserves special attention, and designers and evaluators need appropriate guidelines as well as effective evaluation methodologies to be able to design and to evaluate usable interfaces, respectively.

This paper introduces eLSE (e-Learning Systematic Evaluation), a methodology aiming at increasing the reliability and the effectiveness of e-learning evaluation by proposing a structured and systematic

approach to it. eLSE methodology systematically combines inspection with user-testing. The main novelty of this methodology is the use of evaluation patterns, called Abstract Tasks, which precisely describe the activities to be performed during inspection. For this reason, it is called AT inspection. ATs precisely describe which objects of the application to look for, and which actions to perform during the inspection in order to analyse such objects. In this way, even less experienced evaluators are able to come out with more complete and precise results. In order to perform a more systematic evaluation, the proposed approach concentrates separately on two different aspects of an e-learning application: the platform and the educational modules. An empirical validation of the AT inspection have showed a promising advantage of the AT inspection over the user-testing and heuristics evaluation, demonstrating that ATs are efficient tools to drive evaluators and improve their performance.

The paper has the following organization. First, contributions of some researchers in the domain of e-learning systems evaluation are reported. The eLSE (e-Learning Systematic Evaluation) methodology is described in Section 3. Sections 4 explains how the eLSE methodology suggests to perform the evaluation process. Section 5 identifies the Abstract Tasks to evaluate e-learning systems. Finally, Section 6 concludes the paper.

2 - RELATED WORK

A consolidated evaluation methodology of e-learning systems does not yet exist, or at least it is not well documented and widely accepted. Dringus (1995) proposes to use heuristics without further adaptation to the e-learning context. Similarly, Parlangeli et al. (1999) evaluate e-learning systems by using usability evaluation methods (Nielsen's heuristics (Nielsen, 1993), User Evaluation of Interactive Computers System Questionnaire (Shneiderman and Plaisant, 2004)) that were developed to address needs and challenges of users of interactive systems, i.e. not specific to e-learning.

Other researchers have highlighted the need to develop evaluation methodologies and techniques to the context of e-learning. Notess (2001) asserts that usability testing needs additional consideration in the light of the web-based learning environments, such as learner satisfaction with the learning content, learner perception of the applicability of the content, learner enjoyment of the learning experience, and actual learning, measured via tests. Squires and Preece (1999) propose an adaptation of Nielsen's heuristics (Nielsen, 1993), called *learning with software heuristics*, taking into account socio-constructivism tenets (Soloway et al., 1996).

Quinn, Alem, and Eklund propose a methodology for evaluating e-learning systems that considers design factors and acceptance factors: the former comprises instructional goal, instructional content, learning tasks, learning aids, and assessment, whereas the latter include level of motivation to use the product, level of active participation entailed, quality of learning support, and level of user satisfaction (Quinn et al., 1997).

To conclude the present discussion, it can be claimed, in agreement with other authors, that the number of studies devoted to identify usability issues of e-learning systems is not large and not proportioned to the importance of the e-learning (Quinn et al., 1997; Storey et al., 2002). Moreover, it is often the case that the proposed criteria are only vaguely stated, so that an actual measurement is left to subjective interpretation and implementation. This is a general problem, especially when evaluation is based on heuristic techniques. There is a need to systematize the evaluators' work, providing tools to produce more objective outcomes.

In the next section, a methodology for the evaluation of e-learning systems is presented that solves some drawbacks of heuristic evaluation, and systematizes the work of the evaluators.

3 - eLSE METHODOLOGY

eLSE (e-Learning Systematic Evaluation) methodology aims at increasing the reliability and the effectiveness of e-learning evaluation by proposing a structured and systematic approach to it.

Three important characteristics of this methodology are explained below.

1. eLSE couples inspection and user testing, to make an evaluation more reliable and still cost-effective. Each evaluation process

starts by having evaluators inspecting the application and identifying possible problems and troubles. The user testing is then conducted, whenever necessary, to validate the inspection findings with real users. Since user testing is designed on the basis of the inspection results, it is better focused and the user resources are optimized. As a result, the evaluation is less expensive.

2. eLSE suggests to analyze an application along specific dimensions that address the appropriateness of design with respect to the peculiar nature and purposes of the e-learning systems.

1. The inspection used in eLSE is based on the use of ATs that are specifically defined for e-learning systems. These ATs were defined by considering the literature on e-learning, results of users studies (Ardito et al., 2006), and the experience of usability experts.

4 - A STRUCTURED ACTIVITY FLOW

According to eLSE methodology, the activities in the evaluation process, regardless of which analysis dimension is being considered, are organized into a *preparatory phase* and an *execution phase*. The preparatory phase is performed only once for each analysis dimension; its purpose is to create a conceptual framework that will be used to carry out actual evaluations. The output of the preparatory phase can be easily shared among different evaluators, or different evaluation laboratories that have similar interests and evaluate such applications from similar points of view. The preparatory phase consists of the definition of a library of ATs specific for the e-learning domain. The execution phase is performed every time a specific application must be evaluated. It mainly consists of inspection, performed by evaluators. If needed, inspection can be followed by user testing sessions, involving real users. At the end of each evaluation session, the evaluators must provide designers and developers with an organized evaluation feedback.

The activities in the two phases are described in the following sections.

4.1 - The preparatory phase

In the preparatory phase, a number of decisions must be taken and the definition of a specific set of Abstract Tasks must be carried out.

Abstract Task formulation

eLSE prescribes firstly identifying a number of analysis dimensions specific of the application domain. For each dimension, general usability principles are broken down into finer-grained quality criteria (ISO 9241, 1998) suited to address e-learning issues. By considering the literature on e-learning, results of users studies, and the experience of usability experts, a number of specific guidelines have been identified and associated to these criteria, to be taken into account during the initial design phase. Then, a set of Abstract Tasks addressing these guidelines is identified.

An Abstract Task (AT) is an *evaluation pattern*, which make possible to maximize the reuse of the evaluator's expertise. Its goal is to capture usability inspection expertise, and to express it in a precise and understandable form, so that it can be easily "reproduced", communicated, and exploited. The term "abstract" is used since: i) the activities specifications are formulated independently of the particular application, and ii) they refer to categories of application constituents, more than to specific constituents.

ATs are formulated following a specific template, which includes five items:

- *AT Classification Code and Title*: they univocally identify the AT, and succinctly convey its essence.
- *Focus of Action*: it shortly describes the context, or focus, of the AT, by listing the application components that are the evaluation entities.
- *Intent*: it describes the problem addressed by the AT and its rationale, trying to make clear which is the specific goal to be achieved through the AT application.
- *Activity Description*: it describes in detail the activities to be performed during the AT application.
- *Output*: it describes the output of the fragment of the inspection the AT refers to.

Optionally, a comment is provided, with the aim of indicating further ATs to be applied in combination, or when available, significant examples of inspection findings should be

reported, to better clarify which situations the evaluators should look for while applying the AT activity.

Our approach aims at evaluating both e-learning platform and educational modules. The e-learning platform is the software environment that usually offers a number of integrated tools and services for teaching, learning, communicating, and managing learning material. The educational modules, also called Learning Objects, are the specific learning material provided through the platform. ATs defined for the platform differ from those ones defined for e-learning modules, since different features need to be considered (Ardito et al., 2006, Lanzilotti, 2006).

The ATs are organized in two groups: ATs for evaluating the platform (the container) and ATs for evaluating the educational module (the content). Each group is further divided in *categories*. Such a categorization helps the evaluators to easily identify the ATs that address the evaluation aspects they are interested in.

4.2 - The execution phase

Execution phase activities are carried out every time an e-learning system must be evaluated. They include two major jobs: a *systematic inspection* and a *user-based* evaluation. The systematic inspection is a mandatory activity which is executed first. It produces a list of problems, such as design incompleteness, inconsistency, and irregularity. Oftentimes, inspection results are "obvious" flaws, which require obvious fixing. In some cases, however, some results may need major confirmation with respect to user semantics. In these cases, user-based evaluation sessions are conducted. The last activity in the execution phase is the *evaluation feedback*, which follows the systematic inspection and the user testing (when conducted).

Systematic Inspection

Systematic inspection is performed by evaluators.

During the inspection, the evaluator uses the ATs to perform a rigorous and systematic analysis and produces a report in which the discovered problems are described, as suggested in the AT. The list of ATs provides a systematic guidance to the evaluator on how to inspect an application. Most evaluators are very good in analysing certain features of interactive applications; however, they often neglect some other features, strictly dependent on the specific application category. Exploiting a set of ATs ready for use allows evaluators with limited experience in a particular domain to perform a more accurate evaluation.

User-based evaluation

In eLSE, user-based evaluation is conducted, whenever necessary, to validate the inspection findings with real users. The most peculiar activity, with respect to the traditional approaches, is the definition of *Concrete Tasks* (CTs for short), which describe the activities that users are required to perform during the test. CTs derive from the activity description of the ATs and from the results of inspection.

Since the AT activity description is a formulisation of the user tasks, starting from this it is immediately possible to formulate experimental tasks which can guide users in the critical situations encountered by the evaluators during inspection. CTs are therefore conceived as a means of actually verifying the impact, upon the users, of the specific points of the application that are supposed to be critical for e-learning quality. In this sense, they make user-based evaluation better focused, so optimizing exploitation of the users resources and helping to obtain a more precise feedback for designers.

During evaluation execution, a sample of users is observed while they are executing CTs and relevant data are collected (users' actions, users' errors, time for executing actions, etc.). The outcome of this is therefore a collection of raw data. In the result summary, these data are coded and organized in a synthetic manner and then analyzed.

Evaluation feedback

The last activity of the execution phase aims at providing the designers and developers of the application with an organised *evaluation feedback*. The result of this activity is an evaluation report describing the problems detected, possibly revised in the light of the user testing outcome, using the terminology provided in the AT for referring to system objects or interface elements, and for describing critical incidents. This standardised

language increases the precision of the report and decreases the risk of misunderstandings.

In the following, the Abstract Tasks identified for evaluating e-learning systems are illustrated.

5 - ABSTRACT TASKS FOR E-LEARNING SYSTEMS

eLSE proposes the use of a peculiar inspection technique, called AT inspection, which exploits evaluation patterns, called Abstract Tasks (ATs), to guide the evaluators in their inspection activities. For this reason it is called AT inspection.

Some ATs have been derived that support the inspector evaluating specific components of the e-learning system.

Two ATs categories have been identified:

- *Quality in use* analyzes the technological and structural characteristics of an e-learning system. These ATs, referring to the ISO 9126 and ISO 9241 standards, support the evaluations of effectiveness, efficiency, security, productivity, and satisfaction (ISO 9126, 1991; ISO 9241, 1997).
- *Contents learnability* refers to the capacity of the e-learning platform to allow learners to learn the presented contents and to the LO capacity to transfer the course content to the learners and to make it understandable in a satisfactory way.

For both categories, ATs for the platform and ATs for the LO have been defined.

ATs are subdivided into *basic* (B) and *advanced* (A). Basic ATs aim at supporting evaluators while analyzing the basic features of the application objects and behaviour. On the other hand, advanced ATs are used for a more detailed analysis of the application characteristics.

ATs for evaluating e-learning platforms are reported in Section 5.1, and ATs for evaluating Learning Objects in Section 5.2.

5.1 - Abstract Tasks for e-learning platform

The quality in use category proposes to evaluate:

- the readability and clarity of the media, the validity and opportunities that the communication tools offer
- the ease and the immediacy of the platform access, the platform use by users with physical impairment, the absence of technical problems, and the compatibility with other available software
- the availability and the quality of scaffolding.

Contents learnability category proposes to evaluate:

- the support for personalization of the learning paths and the motivation provided to learners to induce them to use the on-line learning
- the educational support offered to the tutor
- the authoring tools for inserting new educational contents
- the tools available for stimulating the learner's attention.

Table 1 reports the code and the title of ATs for the quality in use and the content learnability categories.

The letter "P" coming before the AT code shows that that AT refers to platform features.

In the following, two examples of ATs are reported. The first is an AT example of the quality in use category and the second an example of the content learnability category.

P_QU_02: Graphical interface elements
Focus of action: interface graphical elements
Intent: to analyze that the platform interface from the graphical viewpoint
Activity description:

- Analyze:
  the colours
  the use of flashing or sliding inscriptions
  the characters font and size
  the coherence of the platform pages.

Output: a list reporting if:

- there is an exaggerated use of different colours
- there is an exaggerated use of forms of distraction (flashing or sliding inscriptions)
- the characters are easily readable
- the different platform pages are coherent.

P_CL_05: Authoring tools ease of use
Focus of action: authoring tools
Intent: evaluate the introduction modality of new educational material
Activity description:

- Use authoring tools to define new contents
- Try to insert a new document testing all commands available

– In a specific moment, verify that the correct feedback is given and that there is the possibility to verify the introduction procedure phase
– Once the introduction procedure is finished, try to access the new document to verify that the operation has been correctly concluded
– Try to update a document that has been just inserted.

Output: a description reporting:

– The possibilities offered and/or not offered
– If there is a mechanism that permits the creation of document in standard formats (AICC, IMS, SCORM)
– If the material updating is facilitated
– The difficulties encountered during the insertion of new documents
– If it is simple to update the material just inserted.

Category: Quality in Use (QU)	
B/A	**AT code and title**
B	P_QU_01: Ease of use
	P_QU_02: Graphical interface elements
	P_QU_03: Recognizability of interface elements
	P_QU_04: Functionality of the navigation tools
	P_QU_05: Availability of media
	P_QU_06: Coherence of media
	P_QU_07: Availability of mechanisms for accessing learning material
	P_QU_08: Availability of communication tools
	P_QU_09: Ease of accessing for users with physical impairments
	P_QU_10: Management of errors
	P_QU_11: Respect for compatibility requisites
	P_QU_12: Availability of tools for estimating learner satisfaction
	P_QU_13: Availability of scaffolding
	P_QU_14: Availability of help
A	P_QU_15: Accuracy of media design
	P_QU_16: Adaptability of the communication tools
	P_QU_17: Frequency of the use of the communication tools
	P_QU_18: Attenuation of scaffolding
	P_QU_19: Quality of the interaction among learners
	P_QU_20: Quality of the interaction lecturer-learners
	P_QU_21: Management of the user profile
	P_QU_22: Speed of access time
Category: Content Learnability (CL)	
B	P_CL_01: Availability of tools for assessing the learner's basic skills
	P_CL_02: Availability of tools for observing the learner's motivations
	P_CL_03: Personalization of the learning path
	P_CL_04: Ease of access of the repository
	P_CL_05: Authoring tools ease of use
	P_CL_06: Internal organization of the course
	P_CL_07: Availability of tutor supports
A	P_CL_08: Availability of tools for stimulating the learners attention and interest
	P_CL_09: Advanced personalization of a document

Table 1. Quality in Use and Content Learnability for e-learning platforms

5.2 - Abstract Tasks for learning objects

Quality in use ATs for LOs propose to evaluate:

– the availability of media and the validity and possibilities offered by the navigational tools
– scaffolding quality available for learners.

The content learnability category for LOs proposes to evaluate:

– the personalization tools offered by the LO
– the aspects related to the content completeness, correctness, and so on.
– the interaction aspects among the learners and the educational materials
– the course internal structure
– the evaluation tools.

Table 2 reports the code and the title of ATs for the quality in use and the content learnability categories.

The letter "LO" coming before the AT code is used to show that that AT refers to learning objects features.

In the following, two examples of ATs are reported. The first is an AT example of the quality in use category, the second an example of the content learnability category.

LO_QU_29: Presentation of the educational content
Focus of action: educational content
Intent: to verify that there are content alternatives using different media
Activity description:
– Verify that:
  the characters size does not obstruct the readability
  the text is accompanied by audio files
  the text is accompanied by video files
Output: a description reporting if:
– The characters are easily readable
– The text is accompanied by audio files
– The text is accompanied by video files.

LO_CL_12: Appropriateness of the language
Focus of action: educational content
Intent: to verify the language used in the text of a selected topic
Activity Description:
– Choose a topic
– Analyze content from a language point of view
– Simulate inability to understand a term and try to look for its definition
Output: a description reporting if:
– The language used is appropriate to the target user
– Difficult terms are defined in the text (before their use) or in a glossary.

Category: Quality in Use (QU)	
B/A	**AT code and title**
B	LO_QU_23: Ease of use
	LO_QU_24: Graphical interface elements
	LO_QU_25: Recognizability of the interface elements
	LO_QU_26: Functionality of the navigational tools
	LO_QU_27: Availability of media
	LO_QU_28: Coherence of media
	LO_QU_29: Presentation of the educational content
	LO_QU_30 Availability of scaffolding
A	LO_QU_31: Accuracy of media design
	LO_QU_32: Attenuation and choice of the media channels
	LO_QU_33: Attenuation of the scaffolding
Category: Content Learnability (CL)	
B	LO_CL_10: Organization of the page
	LO_CL_11: Correctness of the content
	LO_CL_12: Appropriateness of the language
	LO_CL_13: Availability of exercises
	LO_CL_14: Availability of evaluation tools
	LO_CL_15: Frequency and regularity of content updating
	LO_CL_16: Clarity of the course goals and pre-requisites
	LO_CL_17: Adequacy of the educational content to the learners target
	LO_CL_18: Feedback of evaluation tools
	LO_CL_19: Availability of cognitive strategies
A	LO_CL_20: Completeness of the content
	LO_CL_21: Adequacy of the educational model
	LO_CL_22: Quality of references
	LO_CL_23: Respect of the priority constraints
	LO_CL_24: Application of the content to real situations
	LO_CL_25: Feedback of the evaluation tools results
	LO_CL_26: Quality of the interaction between learner and educational contents

Table 2. Quality in Use and Content Learnability for learning objects

6 - DISCUSSION AND CONCLUSION

Various evaluation methodologies and techniques can be considered and applied for evaluating e-learning systems. The paper has discussed issues related to evaluation of this particular class of applications. In particular, we have proposed an evaluation methodology, called eLSE (e-Learning Systematic Evaluation), that prescribes a structured flow of activities. eLSE suggests that reliable evaluation can be achieved by systematically combining inspection with user-based evaluation and it precisely indicates how to combine them to make evaluation more reliable and still cost-effective.

eLSE proposes an inspection technique aiming at allowing inspectors, possibly not having a wide experience in evaluating e-learning systems, to perform accurate evaluations. It is based on the use of evaluation patterns, called Abstract Tasks, which precisely describe the activities to be performed during inspection. For this reason, it is called AT inspection.

The advantage of the AT inspection over other evaluation techniques has been demonstrate by a controlled experiment. Seventy-three participants were divided in three groups that were asked to evaluate a commercial e-learning system by applying the AT inspection, or the traditional heuristic evaluation, or a thinking aloud technique. The experiment results have shown that ATs are effective and efficient tools to drive evaluators and improve their performances (Lanzilotti, 2006). Moreover, the AT inspection is capable to address specific issues of e-learning better than other techniques exploited in the experiment.

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