Evaluation of Interaction Design in Web-Based Intelligent Tutoring Systems

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Abstract. Regardless of so much publicity and activity, the progress in the field of e-learning has been very slow with related problems mostly associated with poor design of e-learning systems. Moreover, due to a low perceived importance of usability, carrying out usability studies in this area is not very frequent, despite the significant role of usability evaluation.

The paper emphasizes the central role of user interface design in e-learning systems, targeting the improvement of the learning experience and the increase of a system's intelligent behaviour as well. The evaluation techniques used for the assessment of operational Web-based system for intelligent tutoring, as well as the evaluation procedure along with the achieved results is introduced. This usability study enabled us to focus on the design of usable interactive learning environments and systems for intelligent tutoring, since it is a known fact that so far the focus was more on the technology and not on user-centred aspects.

Keywords. E-learning, Intelligent tutoring systems, User interfaces, User-centered design, Usability evaluation.

1. Introduction

The evolution of the computer from computational machine to 'knowledge machine' influences a change of current computer-mediated human activities and a development of diversity of new ones such as access to on-line information, on-line health services, e-commerce, e-learning and the like. E-learning, as instructional content or learning experience delivered or enabled by electronic technology [16], is placed on the crossroads between information and communication technology (ICT) and education. Consequently, due to this great impact of ICT on learning and teaching, the traditional definition of an educational system is subject to significant changes, identifying three major roles of computers in education: the computer as subject of teaching, the computer as the tool for supporting the teaching process and the computer as the teacher itself [6]. In order to realize the latter role, computers in the learning and teaching process greatly rely on artificial intelligence techniques, allowing student intelligent guidance and are labelled intelligent tutoring systems (ITSs) [2]. Although argued that such systems certainly have improved the process of learning and teaching [7], it is an accepted opinion that ITSs' interaction mechanisms have been given inadequate consideration. Their user interface design is still poor and inherently complex, especially when supporting student interaction because of students dealing with concepts – specific domain knowledge – yet not understood very well.

The design of user-centered interfaces, which will afford suitable means for usable access to every computer and intelligent tutoring system as well, has to encompass usability evaluation [14]. The paper presents results of just a part of our comprehensive ITSs' evaluation study, targeting the detection of difficulties and potential weaknesses of Web-based ITSs. Ease of use, ease of learning as well as general user satisfaction, along with quality and comprehensiveness of content and ITS's functional capabilities, will determine the success or failure of this effort. Our experience indicates that a particularly useful usability assessment can be performed reasonably fast and easily, for almost no cost other than employees' time.
In this paper we elaborate on the usability of an operational Web-based system for intelligent tutoring. As a practical result, the study should lead to suggestions for redesigning some parts of the evaluated system and on a more general level this result should provide some guidelines on how to design certain aspects of systems for intelligent teaching and learning. The remainder of the paper is structured as follows. Section 2 concisely introduces intelligent tutoring systems, stressing the necessity for their usable user-centered design. Usability study of the working Web-based system for intelligent tutoring is introduced in Section 3, while Section 4 offers concluding remarks.

2. The necessity for user-centered design in intelligent tutoring

Regardless of so much publicity and activity, the progress in the field of e-learning has been very slow with related problems mostly associated with poor interface design of e-learning systems [26]. In order to improve the learning experience and increase a system’s intelligent behaviour, current reports emphasize the central role of user interface design [3]. Furthermore despite the significant role of usability evaluation, carrying out usability studies in the area of e-learning is not very frequent [21] and a consolidated evaluation methodology does not yet exist [4].

In the following, a brief introduction to intelligent tutoring systems and our related work is followed by a concise literature review on e-learning usability and its assessment.

2.1. Intelligent tutoring systems

Although computers are being used at different levels of the teaching process (as the subject of teaching as well as a tool for supporting the teaching process), despite decades of research their use for tutoring (as the teacher itself) in an everyday teaching environment has been quite limited [11]. When talking about a computer as the teacher itself, we are having in mind intelligent tutoring systems (ITsSs) [2]: systems which attempt to mimic the behavior of a human tutor, teaching individually in a one-to-one relationship [6].

Regardless of our expertise and experience, which arise from a number of developed systems for intelligent tutoring [24], [19], [8], presently in use at the University of Split, Department of Computer Science, in the process of teaching and learning for a number of real subjects, we are still facing problems which need to be considered. Although these systems have enriched the tutoring and enhanced the process of knowledge acquisition, there are indications of difficulties in understanding some of their aspects, both by teachers and their students. In order to cope with those issues a more or less standard usability assessment and study has been carried out at the Department. A strong stimulus to our initiative also came from reports stating that very little usability testing has been under way in the design of e-learning technologies, mostly due to a low perceived importance of usability (cf. [21]).

2.2. Significance of usability assessment

To enable and facilitate a design according to usability engineering principles, usability evaluation plays the fundamental role in a human-centered design process (cf. [14]). Numerous different approaches to the assessment and measurement of interaction between users and systems are known from the literature, while every one of them considers usability in terms of a number of criteria. Moreover, usability as quality of use in context [1] should be viewed as comprising of two basic aspects: (i) efficacy in use considered primarily as involving measures of (human) performance and (ii) ease of use considered primarily as involving subjective judgements [20].

The same practices followed by the HCI community can be used to ensure learnability as the major issue for e-learning [18], also implying the employment of user-centered design practices that HCI specialists teach [12]. However, although usability is also the basic parameter for the evaluation of e-learning technologies and systems [27], the idea of e-learning usability is still quite new [18].

Regarding usability evaluation methods, it has been claimed that usability assessment needs further consideration of the learning perspective [15]. There are approaches adapted to e-learning [22], although some authors propose applying heuristics without further adjustment to the e-learning context [5], [17]. Obviously, there is a need for further research and empirical validation [23], since an established set of heuristics [28], as well as a joint evaluation methodology for e-learning applications, does not yet exist [4].
In the light of these considerations, a usability evaluation technique used for the assessment of Web-based systems for intelligent tutoring engaged at our Department in the process of teaching and learning, as well as the evaluation procedure along with the results achieved is described in the following.

3. Employing usability assessment in order to improve an ITS design

Due to the fact that carrying out usability studies in the area of e-learning is not very frequent, as well as taking into account that usability can be significantly quantified during task performance and that it is better to perform any kind of usability assessment than no testing at all, we selected an approach which consists of user walkthroughs of the system interface, guided by predefined steps. Accordingly, usability evaluation of operational Web-based systems for intelligent tutoring is based on criteria expressed in terms of:

- objective performance measurement of effectiveness (the correctness and completeness with which users achieve specified goals) and efficiency (the resources expended in relation to the correctness and completeness of goals achieved) in system use, as well as
- users’ subjective assessment of system usage,

Usability evaluation is thus accomplished by usability testing with real users. Such testing provides information on the way users use the system and identifies the exact problems with the particular interface being evaluated (cf. [14]).

Distributed Tutor-Expert System (DTEx-Sys) is a Web-based intelligent tutoring system which enables students to learn diverse domain knowledge, test themselves, be advised on further work, consult a teacher and access help when needed (see Figure 1), all within an interactive learning environment [19]. An approach to its usability evaluation is derived from the one used to carry out an assessment of an on-site arbitrary domain knowledge generator [8], additionally enhancing user testing with a

Figure 1. Snapshot of DTEx-Sys, a Web-based intelligent tutoring system
kind of 'less formal' heuristic evaluation (i.e. guideline evaluation). A major strength in such an approach is the chance to supplement results from both the guideline evaluation and the empirical user-based one, enhanced by users' feedback on their comfort while working with the system. Consequently, DTEx-Sys evaluation assessment embraces:

- a scenario-based end user testing,
- a usability satisfaction questionnaire and
- a guideline evaluation using a set of metrics/guidelines.

A scenario-based usability test involves representative end-users (here including students) and scenarios designed to cover the major system functionality and to simulate expected real life usage patterns when learning and testing specific domain knowledge. Thus a measurement of task correctness, recognition memory and recall memory is provided, as well as how much and in what time students actually learn, expressed through achieved knowledge and quiz solving time attributes respectively. In order to obtain these measures, a scenario-based usability test comprises: (i) three search tasks, (ii) a short examination after some time spent working with the system and (iii) a quiz to test the achieved knowledge. The usability questionnaire, with questions formulated according to the ones from the literature, supports assessment of users' subjective satisfaction with the interface, their satisfaction with its ease of use, efficiency and likeability, and with the attitude the system induces in users during its usage. Users indicate a level of their agreement with a questionnaire statement on a seven-point Likert scale.

In order to overcome the problem of not having enough usability experts (three to five recommended for heuristic evaluation) who could be involved in the evaluation process, we had a guideline evaluation performed by 'instant experts' [25], computer scientists who learnt the evaluation methodologies and applied them successfully. A set of guidelines, derived through literature overview (e.g. [13]; [10]), was adjusted to the e-learning context and applied as a checklist. The experts had to respond on whether the system was considered to fulfil the guideline ('Done', scored as 7) or more work is needed ('Has to be done', scored as 1) on a seven-point scale.

We carried out the assessment procedure in parallel with three separate groups. The first one was a group of three 'instant experts' involved in guideline evaluation. While inspecting DTEx-Sys's user interface, experts were identifying potential usability problems, 'linking' each problem found to the specific guideline it violated. The second and the third evaluation group consisted of five Computer Science and Mathematics and five Computer Science and Polytechnics second year students respectively. The experimenter met with the participants to explain the purpose of the evaluation session and to present the assessment overview. The main measurement results achieved through scenario-based usability testing, as well as from a questionnaire on user-interaction satisfaction are presented in Table 1 (current level column shows average values of both student groups).

Since DTEx-Sys's users are learners, we don't need interfaces that support 'doing tasks' but interfaces that support 'learning while doing

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<th>Table 1. DTEx-Sys usability attributes specification</th>
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<td><strong>Measuring Method</strong></td>
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tasks' (cf. [9]). For this reason, crucial measurements were performed like how much of the specific subject matter (achieved knowledge) students actually learn, as well as do students feel efficient while working with the system (subjective satisfaction, questions related to efficiency).

Overall, because DTEx-Sys was developed without employing any usability evaluation, it is not surprising that experts found specific difficulties at almost all levels. They identified problems with the design of an effective home page (currently not establishing site identity); they found that more has to be done on the provision of links on each page to a list of local content, a site map and home page as well as on the provision of visual effects for returning users a visual feedback. Besides, more has to be done on designing for recognition rather than recall, what is also evident from the memory current level score. Looking at the measurements obtained and the usability study carried out, the obvious conclusion emerges – there is a clear need for a DTEx-Sys user interface redesign in order to remove identified difficulties and weaknesses.

4. Conclusion

Despite the present strong insistence on learning experience enabled by ICT, the progress in the field of e-learning has been quite slow. Current reports emphasize the central role of the design of e-learning applications, as well as the need for carrying out usability studies and testing, which should also take into consideration learner-centered aspects.

The objective of this paper is to report the results of a usability study conducted at the Department of Computer Science in order to evaluate Distributed Tutor-Expert System (DTEx-Sys), an operational Web-based intelligent tutoring system. This study enabled us to attempt the development of more usable systems and interactive tutoring environments. Considerable efforts had been invested in our country in both the field of intelligent tutoring and the field of e-learning usability provided results, whose results enabled us to enhance the learning and teaching process at our institution. Regardless of the fact that these systems are involved in the process of teaching and learning in a number of real subjects, there are signs of difficulties in comprehending some aspects, both by students and their teachers.

Even though evaluation results were encouraging, both in terms of user acceptance of the system's features and attitude towards the evaluated system, as well as in terms of the achievement of the initial goals that led to the employment of usability assessment, further research is needed.

5. Acknowledgements

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