A User-Centered Approach for Adaptive Systems Evaluation

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Abstract. This position paper proposes a user-centered approach for the design and the evaluation of adaptive systems. A list of less common, but useful HCI techniques will be presented. After having introduced the peculiarities that characterize the evaluation of adaptive systems, the paper describes the evaluation methodologies following the temporal phases of evaluation, according to a user-centered approach.

1 Introduction

Evaluation of adaptive systems is a crucial stage in their development. Different authors [16], [17], [8], [20], [36] have underlined the importance and the difficulties of this task, as well as the lack of empirical studies and strong models to follow. More than others, adaptive systems strongly require some kind of evaluation, due to their inherent usability problems [17], [18]. Therefore, adaptive systems evaluation has to be seriously taken into account, both for usability problems at the interface and for the correctness of adaptive solutions.

Concerning the empirical evaluation of adaptive system, different surveys showed that during the past years only few studies reported statically significant results [8], [35], [13]. The main studies investigating the proper evaluation methodologies of evaluation in user modeling and adaptive systems are concerned with the empirical evaluation [8], layered evaluations of adaptive systems [5], [26], [34], [35], [27], and usability of adaptive interfaces [16], [17], [18].

While these relevant surveys faced with crucial issues of adaptive systems evaluation (controlled experiments, layered evaluation, usability), the main focus of this position paper will be on those HCI methods which are used in the iterative design-evaluation process, and which are often disregarded in the adaptive system evaluation, even if they can offer fruitful results. Indeed, to really bring usability in user-adaptive systems we need to apply all the techniques necessary to realize a user-centered approach. As [18] pointed out, the anticipation and the prevention of usability side effects should form an essential part of the iterative design of user-adaptive systems.

The paper is organized as follows: Section 2 introduces the user-centered design approach, then the paper presents evaluation methodologies following the temporal phases of evaluation, according to a user-centered approach: the requirement phase (Section 3.1), the preliminary evaluation phase (Section 3.2), the final evaluation phase (Section

3.3). For every phase, relevant techniques are described by giving some practical examples of their application in adaptive systems. Finally, Section 4 concludes the paper.

2 The user-centered design approach

Evaluation in adaptive systems seems to be particularly tricky, as well as the interpretation of the collected results, and it is probably more fruitful than for regular systems, especially if carried out since the first design stages. As underlined by [10], iterative design and continual evaluation are a way to overcome the inherent problems of incomplete requirements specification, since not all requirements for an interactive system can be determined from the start, but they can come out during the development phase. This is also the call of the usability engineering approach [37], [23] that states that usability has to be incorporated since the early stages of the design by observing the users and evaluating the system to compensate the inherent requirements lack. Moreover, early focus on users and tasks, continual testing of different solution-prototypes, empirical measurement, and integrated and iterative design can help to avoid expensive design mistakes. All the mentioned principles are also the key-factors of the user-centered design approach [25]: to involve users since the first design decisions of an interactive system and to understand the user's needs and address them in very specific ways. [14] originally phrased this principle as follows: early focus on users and tasks; empirical measurements of product usage; iterative design in the production process.

The user-centered approach can be particularly useful in adaptive systems, where all the evaluation phases can provide feedbacks to modify the knowledge base of the system itself. Thus, evaluation can be considered as a *generative method* [10], since it can offer contributions during the design phase by providing the mean of combining design specification and evaluation into the same framework. Evaluation results can offer insights about the real behavior and the preferences of users, and therefore be adopted in the construction of the user models and system adaptations. Thus, in adaptive systems evaluation it is important not only to test the system, but also because it can become a knowledge source for the adaptive components of the system (e.g., user data acquisition, interface adaptations, inference mechanisms, etc), and can strongly impact them.

Since we believe that the usability engineering methodologies and the user-centered approach can become key factors for a successful design and evaluation of adaptive systems, in this paper the evaluation techniques will be listed according to the life-cycle stage in which they can occur: requirement phase, preliminary evaluation phase, and final evaluation phase.

Notice that the paper focuses on techniques that are seldom exploited in the evaluation and it does not address issues such as usability testing, controlled experiment, since these topics have been already discussed in other relevant studies [17], [8], [18]. Moreover a complete analysis about HCI methodologies and their application and user-adapted systems can be found in [13], which also discusses data collection methods and evaluation metrics for the evaluation of user-adapted system.

3 Phases of evaluation

3.1 The requirement phase

The requirement phase occurs before any system implementation and it can be defined as a "process of finding out what a client (or a costumer) requires from a software system" [29]. During this phase it can be useful to gather data about typical users (features, behavior, actions, needs, etc), the application domain, the system features, etc.

In the case of adaptive systems, the choice of the features relevant to model the user (such as personal features, goals, plans, the real context of interaction, cognitive factors, etc) and consequently to adapt the system, can gain advantages by prior knowledge of the real users of the system, the context of use, and domain experts' opinion. A deeper knowledge of the real users can offer a broader view of the application goals and prevent serious mistakes, especially in the case of innovative systems. As [4] underlined, adaptive systems should benefit more than other systems from the requirement analysis before starting any kind of evaluation, because a higher number of features have to be taken into account in the development of these systems. The recognition that an adaptive capability may be desirable leads to the improved system analysis and design. In the followings, techniques for requirements gathering will be presented.

Task analysis. Task analysis methods are based on breaking down the tasks of potential users into users' actions and users' cognitive processes (for details see [10]). In most cases, the tasks to be analyzed are decomposed in sub-tasks. *Hierarchical Task Analysis* [9], for instance, uses this approach and decomposes tasks in a hierarchy of tasks and sub-tasks, and exploits plans to describe order and conditions of sub-tasks. So far, there has been little experience in the application of this method to adaptive systems, even if task analysis could be used to deeply investigate users' actions and plans in order to decide in advance which phase of the interaction could propose adaptations and how. For instance, if the task analysis shows that the user often performs a set of tasks in the same order (usage patterns) the system could propose shortcuts to speed up the performance. This method can be useful to avoid the well-known cold start problem of knowledge-based systems. If it is possible to individuate different kinds of target users of the system, several task analysis concentrated on representative user groups could be performed in order to investigate the possible adaptations to be proposed to these typical users.

Cognitive and socio-technical models. The understanding of the internal cognitive process as a person performs a task, and the representation of knowledge that she needs to do that, is the purpose of the goal-oriented cognitive models (for details see [10], [29]). Examples of the goal-oriented cognitive model are the GOMS model (Goals, Operators, Methods and Selection) and the derived KLM (Keystroke Level Model). Additional methods for requirements analysis also include socio-technical models, which consider social and technical issues and recognize that technology is a part of a wider organizational environment [10]. The emphasis of these approaches is on social and technical alternatives to problems. For instance, the USTM/ CUSTOM model focuses on establishing stakeholder requirements. Even if seldom applied in the adaptive systems evaluation, both goal-oriented cognitive models and socio-technical models could offer fruitful contributions during the design phase since they are strong generative models [10]. They can help to make predictions respectively about the internal cognitive processes and the social behaviors of users and therefore adopted in the construction of the user model knowledge base and the corresponding system adaptations. For an instance of cognitive models applied in the development of a mixed-initiative framework, see [6] who investigated the performance implications of customization decisions by means of a simplified form of GOMS analysis.

Contextual evaluation. Contextual evaluation is usually organized as a semi-structured interview covering the interesting aspects of a system while users are working in their natural work environment on their own work. Often the interview is recorded in order to be elaborated by both the interviewer and by the interviewee. For more details see [29]. Contextual evaluation is a qualitative methodology that can be applied in adaptive systems evaluation in order to gather social and environmental information (such as structure and language used at work; individual and group actions and intentions; the culture affecting the work; explicit and implicit aspects of the work, etc) useful to design the systems adaptations, especially in the context of collaborative work.

Focus group. Focus group [15], [23] is an informal technique that can be use d to collect user opinions and feedbacks both during the requirement gathering and after the system has been used for a while. It is structured as a discussion about specific topics moderated by a trained group leader. Depending on the users involved (e.g., final users or domain experts/technicians) they can be exploited to gather functional requirements, data requirements, usability requirements, and environmental requirements to be considered in the design of system adaptations. For instance, [12] during the development of an adaptive web-based system for the local public adminstration, developed mock-ups which had been discussed and redesigned after several focus group sessions with experts and final users involved in the project. Focus group can be also used in participative evaluation (see Sec. 3.2).

The systematic observation. The systematic observation [2] can be defined as a "particular approach to quantifying behavior. The aim is to define in advance various forms of behavior (behavioral codes) and then asks observers to record whenever a behavior corresponding to the predefined codes occurs. The observation can be analyzed by adding non-sequential or sequential techniques. In *non-sequential analysis* the subjects are observed for the given time slots during time intervals. Non-sequential systematic observation can be used, for instance, to answer questions about how individuals distribute their time among various activities. In *sequential analysis,* each subject is observed for a given period of time and then behavioral codes are assigned. Sequential techniques are best suited to answer questions about how behavior is sequenced in time and how behavior functions moment to moment. In the adaptive systems evaluation, the systematic observation can be used during the requirement phase to systematically analyze significative interactions in order to discover interaction patterns, recurrent and typical behaviors, user's plans (e.g., sequences of user actions-interactions, distribution of user's activities along the time, etc) that can be modelled by the adaptation. For instance, to model teaching strategies for realizing Intelligent Tutoring Systems, [30] recorded the interactions taking place between the tutor and the student in a natural setting or computer-mediated interface. Then the records were systematically observed to find teaching patterns.

3.2 Preliminary evaluation phase

The preliminary evaluation phase occurs during the system development. It is very important to carry out one or more evaluations during this phase to avoid expensive and complex re-design of the system once it is finished. It can be based on analytical methods (predictive evaluation[1]) or empirical methods (formative evaluation[2]).

Heuristic evaluation. A heuristic is a guideline or a general principle or a rule of thumb that can guide a design decision or be used to criticize existing decisions. Heuristic evaluation [22] describes a method in which a small set of evaluators examine a user interface and look for problems that violate some of the general principles of good interface design. Unfortunately, in the field of adaptive systems a set of recognized and accepted guidelines to follow is still missing. On the one side, this lack can be filled only by publishing statistically significant results that can demonstrate, for instance, that one adaptation strategy is better than another one in a given situation, or that some adaptation technique should be carefully applied. To this purpose, [35] promoted the development of an online database for studies of empirical evaluations to assist researchers in the evaluation of adaptive systems and to promote the construction of a corpus of guidelines. On the other side, also general HCI principles have to be considered. For instance, [19] proposed an integration of heuristic evaluation in the evaluation of adaptive learning environments. They modified the Nielsen's heuristics [23] to reflect pedagogical consideration and then they collocated their heuristics into the level of adaptation proposed by [35]. [18] also faced this problem and proposed five usability challenges for adaptive interfaces to deal with usability problems that these systems can suffer.

Expert review. In the initial implementation phases of an adaptive systems, the presence of domain experts can be beneficial. For instance, a domain expert can help define the dimension of the user model and domain-relevant features. They can also contribute towards the evaluation of correctness of the inference mechanism (see, for instance, [1]) and interface adaptations (see [11]). For instance, an adaptive web site that suggests TV programs can benefit from audience TV experts working in TV advertising that may illustrate habits, behaviors and preferences of homogeneous groups of TV viewers. Experts can also be asked to pick out a set of relevant documents for a certain query and their judgments are used to check the correctness of system recommendations. Expert

[1] Predictive methods are aimed at making predictions, based on experts' evaluation, about the performance of the interactive systems and preventing errors without performing experimental evaluations.

[2] Formative methods are aimed at checking the first design choices and getting the clues for revising the design in an iterative design-re-design process.

review, as well as cognitive walkthrough, scenario-based design and prototypes, can be used to develop *parallel designs* [23], which consist of exploring different design alternatives before setting on a single proposal to be developed further. Parallel design is very suitable for systems that have a user model since in this way designers can propose different solutions (what to model) and different interaction strategies (what the user can control) depending on the identified users.

Cognitive walkthrough. Cognitive walkthrough [28] is an evaluation method wherein experts play the role of users in order to identify usability problems. The focus of the cognitive walkthrough is learning through exploration [10]. Therefore, assuming that a user learns about an interface by exploration, one or more HCI experts select step-by-step tasks and perform the tasks. Then, they have to answer a set of questions about each of the decisions the users must make as they use the interface (for instance, the ease in identifying the system adaptations, the evaluation of the right suggestions towards a goal, etc). As well as reported in the discussion about heuristic evaluation, this predictive technique should benefit from a set of guidelines for adaptive systems that should help evaluators to assess not only general HCI mistakes but also recognized errors in the design of adaptations. Walkthrough can also be performed after an experimental evaluation (post-task walkthrough). The subjects are asked to reflect back after the event and comment on their actions.

Wizard of Oz prototyping. Wizard of Oz prototyping [23], [29] is a form of prototyping in which the user appears to be interacting with the software when, in fact, the input is transmitted to the wizard (the experimenter) who is responding to user's actions. The user interacts with the emulated system without being aware of the trick. Wizard of Oz prototyping can be applied in the evaluation of adaptive systems, for instance, when a real time user-system interaction has to be simulated in the early implementation phases(e.g., speech recognition, interaction with animated agents, etc). For example, [30] in order to model tutorial strategies, used a Wizard of Oz interface that enables the tutor to communicate with the student in a computer-mediated environment.

Prototyping. Prototypes are artifacts that simulate or animate some but not all features of the intended system [10]. Prototypes can be divided into two main categories: *static, paper-based prototypes* that are generally the screen images (screenplay) on paper of what an interface looks like; *interactive, software-based prototypes* that can be an initial implementation of a real system. The software prototypes can be: *horizontal*, when they contain a shallow layer of the whole surface of the user interface; *vertical*, when they include a small number of deep paths through the interface, but do not include any part of the remaining paths; *scenario-based* when they fully implement some important tasks that cut through the functionality of the prototype.

Testing prototypes is very common because this allow designers to make changes before is too late. However, prototyping tools are best used to explore alternative concepts and they cannot be considered as finished products. Thus, testing prototypes with real users is a fundamental stage in discovering the main problems of system adaptations and to consequently refine the adaptations strategies (both at content and interface layer). For instance [12] evaluated an adaptive web prototype, which was vertically developed, in a usability test by involving external users not cooperating at the project. Then, after having solved the usability problems, the final prototype was tested in a controlled experiment with real users representative of the users the Web site was devoted to. The main aims of the test were to discover if the interface adaptations were visible and effective and if the content adaptations were consistent and helpful to the task completion. The results showed the success of both interface and content adaptations and thus the rest of the site was developed accordingly.

Cooperative evaluation. An additional methodology that can be carried out during the preliminary evaluation phase is the cooperative evaluation [21], which includes methods wherein the user is encouraged to act as a collaborator in the evaluation to identify usability problems and their solutions. Even if seldom applied, cooperative evaluation is a qualitative technique that could be applied in the evaluation of adaptive systems to detect general problems (e.g., usability, reliability of adaptations, etc) in early development phases.

Participative evaluation. Another qualitative technique useful in the former evaluation phases is the participative evaluation [23], [29] wherein final users are involved with the design team and participate in design decisions. Participative evaluation is strictly tied to participatory design techniques (user involved in all the design phases, for details see [15]). So far, this methodology is rather disregarded in the adaptive systems evaluation, however it could be applied as an alternative to focus group and prototype evaluation.

3.3 Final evaluation phase

The final evaluation phase occurs at the end of the system development and it is aimed at evaluating the overall quality of a system with final users performing real tasks. As stated in Section 2, relevant discussions about quantitative evaluation methodologies (usability, testing, controlled experiments) for the final evaluation has already been proposed [17], [17], [8]. In the followings will be only described qualitative methodologies that can be used in in the final phase.

Ethnography. Sustainers of qualitative approaches affirm that lab conditions are not real world conditions and only observing users in natural settings can detect the real behavior of the users. For qualitative researchers a subject cannot be reduced to a sum of variables and therefore a deeper knowledge of a small group of subjects is more useful than an empirical experiment with a representative sample. Qualitative methods of research often make use of ethnographic investigations, also known as participant-observation[3].
Ethnography is a qualitative observational technique that is well established in the field of sociology and anthropology. It involves immersing the researcher in the everyday activities of an organization or in the society for a prolonged period of time.

[3] In social sciences, and in particular in field-study research, participant-observation is a qualitative method of research that requires direct involvement of the researcher with the object of the study. For more details see [31].

[29] classify the ethnographic investigations under the umbrella term interpretative evaluation. The interpretative evaluation can be best summed up as ”spending time with users” and it comes in these flavors: *contextual inquiry* (see 3.1); *cooperative evaluation* and *participative evaluation* (see 3.2); *ethnography*, which is concerned with collecting data about the real work situation. The ethnographic approach in HCI acknowledges the importance of learning more about the way technology is used in situ. This implies [21]: the need to use a range of methods including intensive observation, in-depth interviewing, participation in cultural activities,etc; the holistic perspective, in which everything - belief systems, rituals, institution, artifacts, texts, etc. - is grist for the analytical mill; and immersion in the field situation. Different kinds of data sources may be collected as part of this practice, including video, annotations in notebooks, snapshots, etc.

Qualitative methods are seldom applied in the evaluation of adaptive systems. However, as [24] pointed out, statistical analyses are often false, misleading, and too narrow, while insights and qualitative studies do not suffer from these problems as they strictly rely on the users' observed behavior and reactions. Qualitative methods could bring fruitful results, especially in order to discover new phenomena (e.g., by observing the users interacting with a web site in their context new solutions on how to adapt the site can emerge). In fact, qualitative researchers want to comprehend the subjects under the study by interpreting their points of view and by analyzing the facts in depth (intensive approach) in order to propose new general understanding of the reality.

The Grounded Theory. The Grounded Theory is “a theory derived from data, systematically gathered and analyzed through the research process. In this method, data collection, analysis and eventual theory stand in close relationship to one another. The researcher does not begin a project with a preconceived theory in mind (...). Rather, the researcher begins with an area of study and allows the theory to emerge from the data” [32]. The collected data may be qualitative or quantitative or a combination of both types, since an interplay between qualitative and quantitative methods is advocated. See [7] for an application of the Grounded Theory methodology with heterogeneous sources of data (both qualitative and quantitative) in an empirical evaluation aimed at choosing a better way to communicate recommendations to the users in the interface for mobile devices. While for an example in the field of cooperative student model for a multimedia application see [3], who applied the theory to understand the many and complex interactions between learners, tutors and learning environment by integrating the range of qualitative and quantitative results collected during the several experimental sessions.

4 Conclusion

This paper has presented a quick review of methods and techniques for the evaluation of adaptive systems under a user-centered design approach. Considering the state of the art, even though improvement has been registered in a number of evaluation studies in the recent years (see [13]), the evaluation of adaptive systems needs to reach more rigorous level in terms of subject sampling, statistical analysis, correctness in procedures, experiment settings, etc., and also other possible HCI techniques should be considered, such as those ones presented in this paper. Indeed, adaptive systems evaluation studies should benefit from the application of qualitative methods of research and from a rigorous and complete application of user-centered design approach in every development phase of these systems.

References

1. Ardissono L., Gena C., Torasso P., Bellifemine F., Chiarotto A., Difino A., Negro B., 2004. User modeling and recommendation techniques for personalized electronic program guides. In Liliana Ardissono, Alfred Kobsa And Mark Maybury Editors, Personalization and user-adaptive interaction in digital tv, Kluwer Academic Publishers, pp. 30-26.
2. Bakeman R. and Gottman J. M., 1986. Observing behavior: An introduction to sequential analysis. Cambridge: Cambridge University.
3. Barker T., Jones S., Britton C., Messer D., 2002. The Use of a Co-operative Student Model of Learner Characteristics to Configure a Multimedia Application. User Modeling and User-adaptive Interaction 12(2), pp. 207-241.
4. Benyon D., 1993. Adaptive Systems: A Solution to Usability Problems. User Modeling and User-adaptive Interaction (3), pp. 65-87.
5. Brusilovsky P., Karagiannidis, C., and Sampson, D., 2001. The benefits of layered evaluation of adaptive applications and services. In S. Weibelzahl, D. N. Chin, & G., Weber (Eds.), Empirical Evaluation of Adaptive Systems. Proceedings of workshop at the Eighth International Conference on User Modeling, UM2001, pp. 1-8.
6. Bunt A., 2005. User Modeling to support user customization. In Proceedings of UM 2005, LNAI 3538, pp. 499-501.
7. Cena, F., Gena, C., Modeo, S., 2005. How to communicate recommendations? Evaluation of an adaptive annotation technique. Accepted for publication in the proceedings of the Tenth IFIP TC13 International Conference on Human-Computer Interaction (INTERACT 2005).
8. Chin,D.N., 2001. Empirical evaluation of user models and user-adapted systems. *User Modeling and User-Adapted Interaction*, 11(1-2), pp. 181-194.
9. D. Diaper (Ed.). Task analysis for human-computer interaction. Chicester, U.K.: Ellis Horwood, 1989.
10. Dix A., Finlay J., Abowd G. and Beale R., 1998. Human Computer Interaction. Second Edition, Prentice Hall.
11. Gena C. and Torre I., 2004. The Importance of Adaptivity to Provide On-Board Services. A Preliminary Evaluation of an Adaptive Tourist Information Service on Board Vehicles. Special Issue on Mobile A.I. in Applied Artificial Intelligence Journal.
12. Gena C. and Ardissono L., 2004. Intelligent Support to the Retrieval of Information about Hydric Resources. In Proc. of the Adaptive Hypermedia Conference 2004 , Eindhoven, The Netherlands, LNCS. Pp. 126-135.
13. Gena C., in press. Methods and techniques for the evaluation of user-adaptive systems. The Knowledge Engineering Review, accepted for publication.
14. Gould J. D. and Lewis C., 1983. Designing for usability – key principles and what designers think. In Human Factors in Computing Systems, CHI ’83 Proceedings, New York: ACM, pp. 50-53.
15. Greenbaum T. L., 1998. The Handbook of Focus Group Research (2nd Edition). Lexington Books: New York, NY.
16. Höök K., 1997. Evaluating the Utility and Usability of an Adaptive Hypermedia System. In Proceedings of 1997 International Conference on Intelligent User Interfaces, ACM, Orlando, Florida, 179-186.

17. Höök K., 2000. Steps to take before IUIs become real. Journal of Interacting with Computers, vol. 12, no. 4, pp. 409-426.
18. Jameson A., 2003. Adaptive Interfaces and Agents. The Human-Computer Interaction Handbook, Lawrence Erlbaum Associates, New Jersey, pp. 316-318.
19. Magoulas G. D., Chen S. Y. and Papanikolaou K. A., 2003. Integrating Layered and Heuristic Evaluation for Adaptive Learning Environments. In: Weibelzahl, S. and Paramythis, A. (eds.). Proceedings of the Second Workshop on Empirical Evaluation of Adaptive Systems, held at the 9th International Conference on User Modeling UM2003, Pittsburgh, pp. 5-14.
20. Masthoff, J. (2002). The evaluation of adaptive systems. In N. V. Patel (Ed.), Adaptive evolutionary information systems. Idea Group publishing. pp329-347.
21. Monk A., Wright P., Haber J. and Davenport L., 1993. Improving Your Human Computer Interface: A Practical Approach. BCS Practitioner Series, Prentice-Hall International, Hemel Hempstead.
22. Nielsen J. and Molich R., 1990. Heuristic evaluation of user interfaces. In Proceedings of CHI '90, Seattle, Washington, pp. 249-256.
23. Nielsen J., 1993. Usability Engineering. Boston, MA, Academic Press.
24. J. Nielsen. Risks of quantitative studies. In *Alertbox*, http://www.useit.com/alertbox/20040301.html, 2004.
25. Norman D.A. and Draper S.W., 1986. User centered system design: new perspective on HCI. Hillsdale NJ, Lawrence Erlbaum.
26. Paramythis A., Totter A. and Stephanidis C., 2001. A Modular Approach to the Evaluation of Adaptive User Interfaces. In S. Weibelzahl, D. Chin, and G. Weber (Eds.). Proceedings of the First Workshop on Empirical Evaluation of Adaptive Systems, Sonthofen, Germany, pp. 9-24.
27. Paramythis A., and Weibelzahl S., 2005. A Decomposition Model for the Layered Evaluation of Interactive Adaptive Systems. In Proceedings of UM 2005, LNAI 3538, pp. 438-442.
28. Polson, P.G., Lewis, C., Rieman, J., and Wharton, C., 1992. Cognitive walkthroughs: A method for theory- based evaluation of user interfaces. International Journal of Man-Machine Studies 36, 741-773.
29. Preece J., Rogers Y., Sharp H., Benyon D., 1994. Human-computer interaction. Addison-Wesley Pub.
30. Rizzo Paola, Italy Hyokyeong Lee, Erin Shaw, W. Lewis Johnson, Ning Wang, Richard E. Mayer, 2005. A Semi-Automated Wizard of Oz Interface for Modeling Tutorial Strategies In Proceedings of UM 2005, LNAI 3538, pp. 174-178.
31. Spradley J., 1980. Participant Observation. Wadsworth Publishing.
32. Strauss A. L. and Corbin J. M., 1998. Basics of qualitative research: techniques and procedures for developing grounded theory. SAGE, Thousand Oaks.
33. Totterdell, P., and Boyle, E., 1990. The Evaluation of Adaptive Systems. In Browne, D., Totterdell, P., Norman, M. (Eds.), Adaptive User Interfaces. London: Academic Press, pp. 161-194.
34. Weibelzahl S., 2001. Evaluation of Adaptive Systems. In Mathias Bauer, Piotr J. Gmytrasiewicz and Julita Vassileva (Eds.), LNCS n. 2109: User Modeling 2001. Berlin, etc.: Springer, pp. 292-294.
35. Weibelzahl S., 2003. Evaluation of Adaptive Systems. Dissertation. University of Trier, Germany.
36. Weibelzahl S., 2005. Problems and pitfalls in the evaluation of adaptive systems. In S. Chen & G. Magoulas (Eds.). Adaptable and Adaptive Hypermedia Systems (pp. 285-299). Hershey, PA: IRM Press
37. Whiteside J., Bennett J., and Holtzblatt K., 1988. Usability Engineering: Our Experience and Evolution. Handbook of Human-Computer Interaction (M. Helander, ed.), New York: North-HolIand, 1988, pp. 791-817.