Communication & Cognition
Vol. 41, Nr. 1 & 2 (2008); pp.

EVALUATING LEARNING-SUPPORT SYSTEMS USABILITY: AN EMPIRICAL APPROACH

Alexandra Rentróia-Bonito, André Martins, Tiago Guerreiro, Joaquim Jorge

Abstract

Usability is a key attribute affecting information technology systems acceptance and adoption by users in instructional settings. This is due to the system's role as mediator between instructors and learners. Indeed, a basic condition for usable e-learning systems is that users are able to concentrate on the content rather than on the system. This requires integrated, systematic and user-based evaluation to help design learning-centered experiences. However, usability in educational support systems is also affected by contextual factors. Furthermore, methods that address both the technical and pedagogical dimensions in context of use are still a research issue. Such methods might help organizations who want to remain competitive, to identify what factors are most important when adopting technology-supported learning solutions to implement an effective learning process. In this paper, we describe an integrated usability evaluation method empirically tested within an instructional setting at our university. We developed a prototype system to support the internal teaching process and evaluated its role in a technology-supported learning experience. Our results indicate that a learning-support system must adequately meet the needs of the instructional process and support learners' behaviors and actions. These results also show that consistent online and offline communication between stakeholders is crucial to effective learning. While this paper describes ongoing research, we expect that our experience will provide insights and a better understanding on how to evaluate and improve e-learning system usability from learner feedback and usage patterns.

Categories and Subject Descriptors

H.5.2 **[User Interfaces]**: Evaluation /Methodology

General Terms

Measurement, Design, Human Factors.

Keywords

Blended-learning, experience, learning-support systems, Human-Computer Interaction, Usability evaluation, Educational Technology, IT evaluation methods.

1. Introduction

Designing usable course materials for technologically-enhanced learning environments is a challenging task. Indeed, designer concerns about both learning effectiveness and efficiency are driving the search for new ways to approach and evaluate system usability in a more situational manner by taking into account organizational strategy, social and cultural context [2]. Such systems must incorporate technical and pedagogical dimensions [5,8] to foster interactions and collaboration between learning group members. Moreover, designing the learning experience should take into account work- and learner-specific needs [4,7]. However, research is still ongoing on the theoretical underpinnings and integrated development methods to address these issues [3,9,10] within dynamic and ever-increasing competitive pressure towards organizational agility. Currently adopting e-learning solutions pass through blended-learning that allow organizations to learn from practice what works best for them in supporting internal learning endeavors. Within this scenario, situational usability emerges as a key issue for effectiveness.

Usability is defined as the extent to which a system can be exercised in order to achieve specific goals and complete well-defined tasks effectively, efficiently and with satisfaction [4] including its social and cultural context [2]. Usability in learning-support systems adds new dimensions since courseware delivery methods are not the sole driving concern. Indeed, understandability and learnability of a subject are affected by system design, content structure and organization. Therefore, understanding how learners interact with the learning-support systems will contribute to improve the decision-making process, the actions within development teams and the cost-effectiveness of learning. This translates into guidelines to improve systems and the instructional process, while simultaneously influencing their acceptance by learners and enhancing the quality of learning results.

This paper focuses on the interaction between learners and learning-support systems by exploring the people-system fit within instructional settings. Here, we only explore the usability of learning-support systems and how it affects student behavior, actions and satisfaction. Our main goal is to apply an empirical usability evaluation method that combines systematic user testing and technical evaluation, in both quantitative and qualitative ways. To this end, we compare perceived ease of use and usefulness of the system in achieving stated learning goals. Additionally, we study system logs and performance indicators, such as drop-out rates, in a real instructional setting. These views (user actions and access patterns) complement each other and help designers to achieve a holistic perspective of process and system's key issues surrounding the learning experience. Our main contribution is to offer organizations an integrated usability evaluation approach to assist them in adopting cost-effective technology-supported learning solutions. In the remaining part of this article, we present our conceptual framework, results gathered and discuss the implications for design. Finally, we present conclusions and ideas for future work.

2. Conceptual framework

Many organizations view e-learning as a tool to achieve context-specific, work-related and "just-in-time" training. However, results have not shown the expected benefits [7,15]. Moreover, well-founded theories and evaluation methods that embrace accepted and tested usability, *learnability* heuristics and proper design tools remain on the research agenda [4, 7]. Currently this limits our understanding of the dynamics of technology-supported learning experiences within organizational settings, and consequently, impairs the role of e-learning as an effective organizational component to achieve expected business goals.

As a cost-effective approach, we advocate applying a blended-learning solution to deploy e-learning contents. This is because blended-learning combines multiple approaches to pedagogy or teaching. Thus it allows integrating e-learning tools with traditional methods to achieve set learning objectives. Of course this should take into account the different stakeholder needs, preferences and capabilities. Since interaction with humans in blended-learning experiences is usually supported by synchronous and asynchronous tools, from e-tutoring to face-to-face contacts. By adopting blended-learning solutions, organizations expect to enforce cost-effective solutions by: (a) enmeshing learning in their business processes, (b) delivering it on time to the proper target audience, and (c) assertively managing the change process. Work

Deleted: ,

becomes a source of learning contents to be shared among different users performing the same tasks or fulfilling similar roles using the same system in a common context. This setting requires different methods to plan, design and improve learning experiences within a changing business environment. Moreover, this demands a high internal fit between business and instructional processes and learning-support systems. This way, defining learning goals and tasks addressing the identified skill gaps are better supported by system functionalities. Also, content is more effectively produced. This work-related and timely just-in-need learning content must be delivered by usable learning-support systems that are also perceived as useful for learners in context of use. Hence, the process and system fit is adequate, structuring the blended-learning experience.

Deleted: In t

As can be seen in Figure 1, learning-support systems reflect institutional decisions to implement specific organizational strategies to skill development. Examples of these decisions are investments in technology, making expert staff available to produce content, instructional approaches and methods, facilities, instructor support, and also setting high-level system's usability goals. Additionally, instructors' teaching style and context-specific organizational values shape pedagogical methods and contribute to set up the class' sub-culture, which foster learners' expected behaviors and actions [11].

Usability evaluation in learning-support systems should be part of an iterative design approach to address the rapidly evolving and context-specific nature of modern learning contexts and contents. By combining different evaluation methods, perspectives and tools in an integrated way, we help development teams to diagnose and improve the learning experience by capturing and analyzing design-oriented user feedback and recorded learning resource usage data against usability and learning goals. This practice will positively influence both user acceptance enhancing their sense of control and the artifacts surrounding their immediate context of work. In turn, such sense of control will positively affect their behavior, performance and actions [1] when interacting with instructors and peers via learning-support systems.

Given that usability is a necessary but not sufficient condition to effective learning, its technical and pedagogical dimensions poses challenges for development teams. This implies looking at the concept of usable systems in an extended manner interpreting it regarding the stated usability and learning goals from the users' perspective. To accomplish this, our framework takes into account both usability and learning goals. Furthermore, it encourages design-

Deleted: end

oriented user feedback captured by combining inspection evaluation techniques with monitoring learning results, and proposes a specific development kit [13].

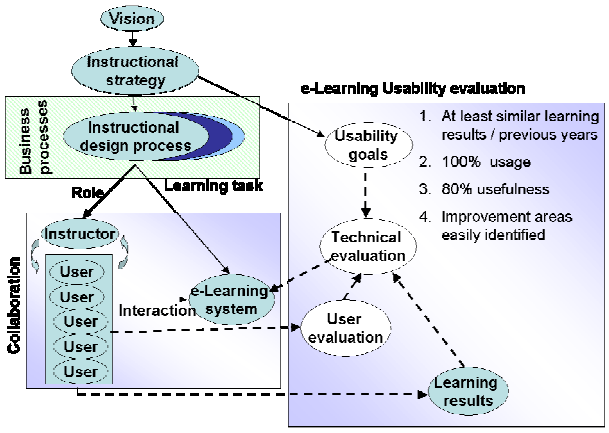

Figure 1 – Conceptual Framework

Higher-education institutions are no exception to competitive pressure to improve results' effectiveness. To test this framework, it was instantiated into a concrete academic experiment in the context of a one-semester course. Even though the dynamics of higher education process are different from professional/business training practices in enterprises, this exercise allowed us to understand the functioning and flexibility of our proposed evaluation framework in a real learning situation. Such understanding could be later validated across different contexts and situations to confirm empirical evidence. In the next section, we describe our study methodology and results.

Deleted: ,

Deleted: is

3. Study Methodology

A research group from our university set up an instructional setting called, for the purpose of this research work, MCP (Multimedia Content Production) Online course. This course is part of the Computer Graphics and Multimedia curricula of the Computer Science Engineering Degree at *Instituto Superior Técnico* the engineering school of the Technical University of Lisbon. Learning content was structured around theoretical concepts and related examples, and was made available to students through slides (Adobe Acrobat/Microsoft

Deleted: in Lisbon

PowerPoint) and multimedia archives of past classes (video, audio synchronized with presentation slides) according to the course program. Learning tasks were defined and system functionalities were activated together with brief working instructions and rules. These tasks were: (1) participating in scheduled classes, (2) studying subject contents (which were made available in a timely fashion on the system according to course´s program); (3) doing a course project, writing periodic reports, participating in its forum and weekly chat; (4) analysing multimedia topics and posting their summaries on a specific thematic forum, and (5) taking quizzes and exams. The system functionalities necessary to support these course tasks were activated. Learners could perform: (a) individual tasks, such as consulting current and archived learning materials, participating in class, *fora*, project support chat, and (b) group tasks, such as doing a project and respective report by using the system's integrated *wiki* component. In addition, students could receive feedback and consult class' information resources also online. MCP Online course is a blended-course combining all elements related to a conventional class scenario within our university setting, entailing all its interdependent organizational dynamics, with a Learning Management System (LMS) adapted to support its internal teaching practice. This course was taught during spring semester (2005/06) in two campi of our university.

The research group selected and customized an open source Learning Management System including a webcast and multimedia archiving functionality, which we called SEMINOLE (SEaMless INtegrated Online Learning Environment). The system prototype was tested within same course last year and was improved according to user and technical feedback [14]. Figure 2 shows a high-level view of system architecture. The system was designed to meet four main requirements: learning content management, class webcast and archive, evaluation methods and collaborative work. Its main functionalities were identified based on defined vision, priorities; university's teaching process and analysis of strengths and weaknesses of available LMS platforms. In short, SEMINOLE was based on an open source LMS, called Moodle [16] integrated with a streaming webcast *and multimedia lesson recording* system (ePresence [17]). The former allowed students to access many different contents, participate in online *fora*, take quizzes, check grades, etc. The latter allowed students to access webcast and archived lecture events in this course. In this way, students could attend classes remotely, by viewing slides which were synchronized with audio and video streams. They could also participate in classes, either through chat-room interacting with both teachers and colleagues or asking questions to teachers through audio. The internal

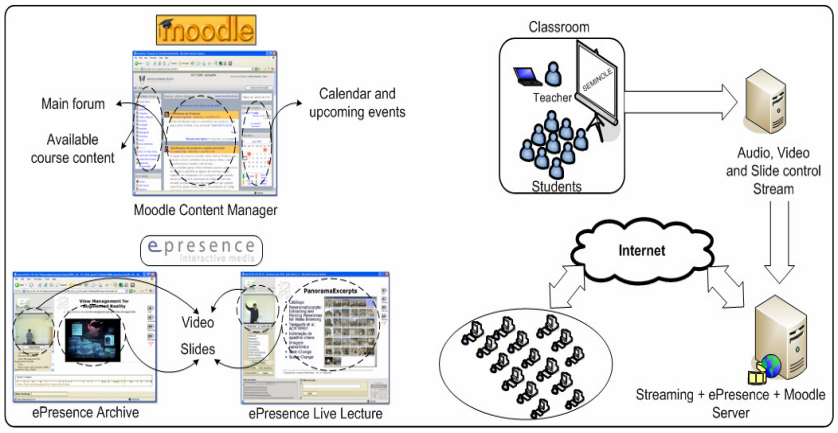

Figure 2 – SEMINOLE Architecture and Screenshots

instructional process and SEMINOLE covered the structural part of our blended-learning experience. After structuring the experience, the instructor team focused on relationship management. Instructor and teaching assistant lectured in a traditional way while opening different communication channels (online and offline), such that the response time to answer questions/doubts concerning class logistics or projects was between 30 minutes - 12 hours. Also, the teaching assistant moderated weekly chat sessions that lasted two hours per session, four times per week, and dedicated between six to twelve hours per week to coach students in project assignments and system functionalities according to defined course deadlines and students' needs in face-to-face meetings.

A total of 143 students registered for this course. Around 66% of them participated to evaluate SEMINOLE's usability, all Portuguese. Of these, 84% were between 24 - 30 years old. Further, 21% were female. 57% were registered at Campus A, the others at Campus B. All reported spending at least 1 hour/day using the Internet of which 79% used it more than 2 hours/day. 82% showed preference to study via Internet when at home. 26% were majoring in Multimedia & Intelligent Systems and 55% major in Information Systems. 73% were in their 4th year of a 5-year undergraduate study course. 82% reported never having previously participated in a similar blended-learning experience. 58% reported to access Internet at speeds between 512 Kbps – 2 Mbps, 29% at speeds over 2 Mbps and 9% at under 512 Kbps. 54% reported to access course's learning-support system more than 4 times per week during this semester; and 44% spent between 6 – 10 minutes / each time. All used their

personal computers for class purposes. Almost a quarter of the students held partial-time jobs.

At the very beginning of the course, students were informed about class dynamics and evaluation methods. This information was also online. Participating students used SEMINOLE as the sole tool to perform main learning tasks. Students used system functionalities according to planned learning tasks and kept up to date with their progress and class dynamics by consulting respective fora and grades. Because of the ratio between instructors/students (2/143) in this class, instructors decided to: (a) include collaboration and communciation tools, such as fora, chat and wiki, to deliver consistent messages, (b) better manage existing pedagogical resources, and (c) sustain expected behaviors and perfomance levels. For example, to do the course project, students participated in the respective forum and weekly chat and used system's wiki to deliver related report. The teaching assistant was thereby able to give all students pertinent feedback, based on their face-to-face project presentation and report, in a maximum of 12-hour period three times during the semester, contributing to students' concentration on what mattered the most in their specific project, and consequently to their overall learning.

Usability evaluation was done in two specific moments after using the system, at the 6th and 11th week of the course (first week of April and May respectively). They filled out an online questionnaire indicating their opinions about: (a) how easy it was to perform each task on the system; and (b) how useful were the tasks performed on the system for their learning. It also had open questions regarding what they liked the most and the least about this blended-learning experience. This questionnaire was previously tested during a similar experience during 2004/05 and was improved based on learner feedback [12]. Students took a quiz and filled out the online questionnaire during the same week spending, on average, ten minutes on each. Anonymity and confidentiality were both stressed and ensured by the research team. The data was analyzed during designers' meetings to identify improvement areas, validate their short-term feasibility and plan their deployment. On the other hand, access-related data recorded during the same period in SEMINOLE was analyzed to detect usage patterns and monitor estabilished course goals.

4. Our results

The assumption underlying this study was that structure drives behaviors, so that a well-structured blended-learning experience could make it easier to

manage the interactions and collaboration among students to achieve expected results. Figure 3 shows the statistical means for each dimension of system's usability assessed in the two user evaluation sessions during the semester. All participating Computer-Science students reported spending at least 1 hour/day using the Internet (79% did so more than 2 hours/day), so they were familiar with asynchronous, synchronous and collaborative tools. They were asked to evaluate the system based on their experience with it by performing the different tasks.

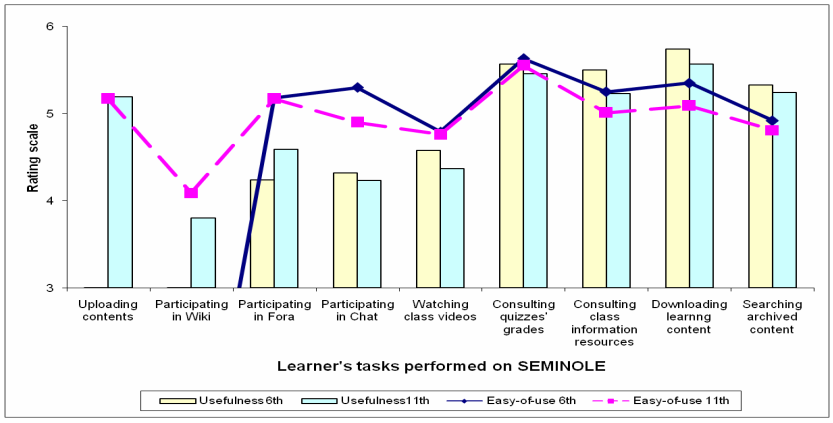

Figure 3 – SEMINOLE Usability

***Usefulness response scale**: **1**=Not useful for me; 2=Very little useful for me 3= A little useful for me; 4= moderately useful for me; 5= Useful for me; 6=Very useful for me*
***Ease-of-use response scale:** 1=Very difficult; 2=Difficult, 3= Moderately difficult; 4= Moderately easy; 5= Easy, 6=Very easy*

Consulting grades and class information resources, uploading, downloading and searching for archived content were perceived as easy tasks to perform and useful for learning across evaluation sessions. Usefulness of consulting archived webcast videos and course information resources also showed significant changes. At the 11th week of the course, these were perceived as a bit less useful than in the previous evaluation session. This may be related to the fact that in May students were more aware of course dynamics and system usage, having formed habits, which minimized the need for this specific information. Though participating in *fora* was perceived as a easy task

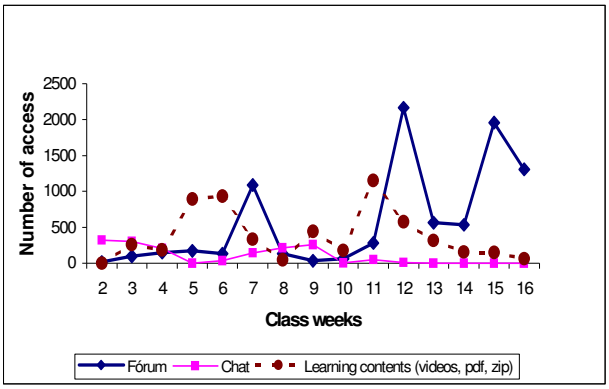

Figure 4 – Total weekly accesses to SEMINOLE

to perform, its usefulness for learning process must be improved. At the 6th week of the course, 55% of participating students reported to have posted nothing in existing *fora*. This situation changed in the next month after students were asked to analyse hot multimedia topics and post their summaries on a specific thematic forum (planned learning task). Also, the increase in *fora* participation indicated that individual requirements were less demanding on cognitive and time resources than participating in chat. Users deemed the wiki functionality to compose project reports as the most difficult and less useful task to perform in SEMINOLE because it lacked many formatting capabilities and went against their usual writing workflow. Students rated the conventional methods, based on stand-alone text processors and offline review, as more suited to the task especially when tight deadlines were involved. Participating in project's chat was perceived as more useful in the second evaluation, although the system required improvements. Students reported that participation in chat was useful to learn general rules of engagement, but the in-class discussions were more useful in clarifying thornier issues. Notwithstanding the increasing demand and complexity of performed tasks on the system, throughout the semester, the perceived ease of use and usefulness of each task held steadily across evaluation sessions.

Figure 4 shows total weekly accesses to SEMINOLE resources including *fora*, chat, and multimedia course contents. In the beginning, synchronous communication to support a course project was both exciting and a novelty. However, as deadlines approached, usage of this tool fell drastically in detriment of face-to-face coaching which became intensively required. In May,

students reported the project chat function to be more difficult to use than in the previous month. This perceived difficulty may suggest that usefulness of chat in learning was related to the specificities of topic, individual interests, priorities and personal availability to synchronize with colleagues and create "a common communication space". System usage data and in-class informal student feedback confirmed this finding. After the second evaluation session, students were asked by the instructor to suggest areas of improvement by commenting on a specific post. Responses covered not only technical aspects, such as a better navigation scheme for webcast videos, but also relationship issues, such as grading each other's posted contributions in the thematic forum. These results related to reported satisfaction with this blended-learning experience. Figure 5 shows student satisfaction. On average, at the 11th week of course, students were slightly satisfied with learning tasks and system's usability which suggested the need for a better fit between the pedagogical process and the system's functionalities in this instructional context. Communication with instructors and peers, instructor support and received feedback were identified as the most satisfying elements of this blended-learning experience which reinforced the importance for consistency in communicative acts and human support. Grades were the least satisfying of the elements even though more than 90% of students did make a passing grade, and significant changes were detected among student course-related project results when compared with those of last year's course.

Regarding stated usability goals, most areas of improvement were related to learning tasks and SEMINOLE's usability. Improvements will be deployed in the next version of the system, thus avoiding interference with the current students' learning process. The most relevant areas for improvements were identified by students as: (a) the navigation scheme and organization of homepage; (b) the navigation interface of the multimedia archive; (c) communication and collaboration in-built tools (chat, wiki and fora) to make them more effective tools for learning, (d) a further exploration of the effectiveness of web quests in this instructional context, (e) the fine-tuning of peer-review and grading scheme to enhance students participation in fora, and (f) more interactivity and better structure available learning contents.

Regarding defined learning goals, our results indicated that, over 90% of the students did make a passing grade. Furthermore, drop-out rate was 1.4% among registered students. Also, we measured an average of six posts to *fora* from students to each post by instructors. Every registered student used SEMINOLE as a learning tool, though at different extents. Out of 16000+

logins to the system, 92.5% were made by students (15000+) and, on average, each student entered seven times per week. Resources such as forum, chat, videos and other learning content were accessed over 127000 times, 86% of which by students, as shown in Figure 4.

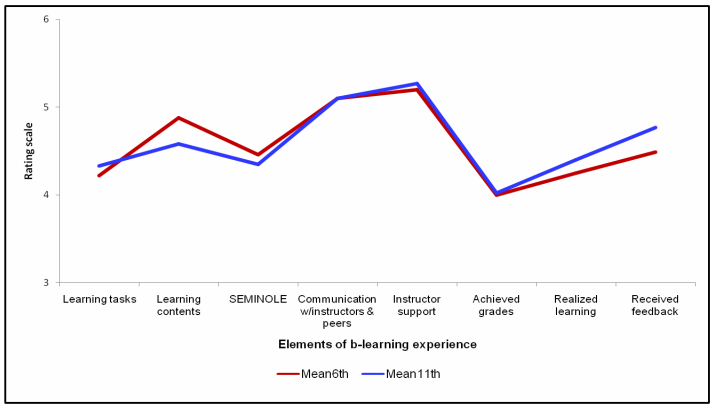

Figure 5 - Student satisfaction with MCP Online course

Satisfaction response scale: *1=Totally unsatisfied; 2=Unsatisfied, 3= Slightly unsatisfied; 4= Slightly satisfied; 5= Satisfied, 6=Very satisfied*

5. Implications for Design

This experience entails four implications for courseware and design as identified. From the pedagogical point of view, well-organized course content and instructional methodologies ease the initial structuring, maintenance and reutilization of online learning materials. Learning tasks and system functionalities should adequately fit to effectively contribute to learning. Also, defining rules and working instructions is not to be underestimated due to its impact on how learners perceive the dynamics of technology-supported learning experiences. Second, from an evaluation standpoint, involving students in the development lifecycle more than a cost-effective tool is also a key factor in sustaining a constructive climate to support active learning. This contributes to recast the roles of students and instructors within the new paradigm of learning. Third, observing and understanding user's reflections on the learning process as they experience it is key variable to our proposed evaluation framework. These techniques will allow us to diagnose, learn from practice and plan the next

steps. The application of this acquired and accumulated knowledge by designers is a key point to ease the transitional phase towards more advanced stages of e-learning in organizational contexts. Last, from a technical standpoint, upgrading the system functionality must match users developed abilities, attitudes and expectations. Specifically, making available new system functionalities should be done when the learning tasks require them. Indeed, this observation came from understanding what users knew in context of use to adjust system functioning to perceived (real), rather than postulated user needs.

6. Conclusions

As previously mentioned, the goal of this work was to present empirical results from applying our approach to evaluate the usability of a learning-support system within a real instructional setting. The approach combines systematic user testing with technical evaluation, in both quantitative and qualitative ways. We expect that these methods will help competitive organizations to cost-effectively manage their technology-supported learning solutions, by incorporating such evaluation techniques within their own context and culture. Our results show that design tools promote a structured and iterative communication space between designers and users to yield a cost-effective approach to integrated courseware development. Indeed, evaluating technology-supported learning experiences in this way allows focusing the development effort by using diagnostic tools that explore both technical and pedagogical issues. Furthermore, this allows evaluating usability in context of use by measuring its impact on users' learning behaviors, actions and satisfaction levels.

Finally, this experience suggests areas for further work which we briefly describe. Experience suggested improvements to distance collaboration tools, including exploring the role of classroom devices such as whiteboards augmented by technology to support synchronous communication in explaining concepts or remotely answering questions to learners. It would also be desirable to compare qualitative and quantitative data from similar blended-learning experiences across user groups and contexts to get empirical results and thus to be able to generalize a model. Furthermore, capturing user data could be done in a more comfortable way by using multimodal interfaces. Also, it would be desirable to search for more specific ontologies to better interpret open responses to questionnaires. This would allow the development team to capture and translate into courseware design, what users know about what they do, learn and value as relevant when interacting with systems. Context and user-specific

Deleted: From these data, context and user-specific heuristics may emerge to complement design guidelines for learning-support systems

heuristics may emerge from this data to complement design guidelines for learning-support systems. Finally, it would be interesting to apply data mining techniques to detect learning patterns and individual learning strategies in order to design learning tools that are more useful, easier to use and better adapted to students.

Deleted: ing

7. Acknowledgments

Tiago Guerreiro was supported by the Portuguese Foundation for Science and Technology, grant SFRH/BD/28110/2006.

8. References

[1] Bandura, A. *Self-efficacy: The exercise of Control.* W.H.Freeman and Company, NY, 1997.

[2] Blandin, B. Usability Evaluation of Online Learning programs: A sociological standpoint. In *Usability Evaluation of Online Learning Programs*. Ghaoui, C. (ed.), USA: Idea Group Publishing, 313-330, 2003.

[3] Costabile, M.; De Marsico, M.; Lanzilotti, R.; Plantamura, V & Roselli, T. *On the Usability Evaluation of E-learning Applications*. IEEE, 2005.

[4] Dix, A., Finlay, J., Abowd, G. & Beale, R. *Human-Computer Interaction*. 3rd. edition. UK: Prentice Hall, 2004.

[5] Duchastel, P. Learnability. In *Usability Evaluation of Online Learning Programs*. Ghaoui, C. (ed.), USA: Idea Group Publishing, 299-312, 2003.

[6] Edutech. Available at www.edutech.org (Retrieved March 2005).

[7] Grant, R. & Danziger, J. (2005). *Exploring the Corporate Benefits and Employee Adoption. Corporate E-learning.* Working Paper. University of Victoria, and University of California, 2005.

[8] Karoulis, A. & Pombortsis, A. Heuristic Evaluation of web-based ODL Programs. In *Usability Evaluation of Online Learning Programs*. Ghaoui, C. (Ed.). USA: Idea Group Publishing, 2003.

[9] Maor, D & Zariski, A. *Is there a fit between technology and pedagogy in online learning?*. Murdoch University, Teaching and Learning Forum, 2003.

[10] Mehlenbacher, B.; Bennett, L.; Bird, T.; Ivey, M.; Lucas, J.; Morton, J. & Whitman, L. *Usable E-Learning: A Conceptual Model for Evaluation and Design*. NC State University, 2005.

[11] Organ, O. & Bateman, T. Organizational Behaviour. Irwin. 4th. Edition, 1991.
[12] Rentroia-Bonito, M. A. & Jorge, J. A. An Integrated Courseware Usability Evaluation Method. In *Proceedings of 7th. Knowledge-Based Engineering Systems International Conference,* Sept 3-4. Oxford, UK: Lecture Notes in Computer Science, 2774 (2). 208-214, 2003.
[13] Rentroia-Bonito, M. A., Jorge, J. & Ghaoui, C. An Overview of an Evaluation Framework for E-Learning. In *Encyclopaedia of Human Computer Interaction*. Ghaoui, C. (Ed.). USA: Idea Group Publishing, 441-450, 2005.
[14] Rentroia-Bonito, M. A., Figueiredo, F; Martins, A; Fernandes, V., & Jorge, J. Web-based support for resource-effective e-learning. *International Conference on Web Information Systems and Technologies.* April 11-13 2006. Setúbal, Portugal, 2006.
[15] Wentling, T., Waight, C., Gallager, J., La Fleur, J., Wang, C., & Kanfer, A. *E-Learning - A review of Literature*. Urbana-Champaign: University of Illinois, 2000.
[16] Moodle Open Source LMS. Available at www.moodle.org (Retrieved March 2006).
[17] ePresence lecture webcast and recording component. Available at: www.epresence.tv (retrieved May 2006)

About the authors

Alexandra Rentróia-Bonito, André Martins, Tiago Guerreiro, Joaquim Jorge, INESC-ID, R. Alves Redol, 9, 1000-029, Lisboa, Portugal, +351 213100263, {arentroia, apmart, tjvg, jaj}@immi.inesc.pt.