Evaluating Learning Support Systems Usability
An Empirical Approach

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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 communication mediator between instructors and learners. Indeed, a basic condition for usable e-learning systems is that users are able to concentrate on content and not on system issues. This demands an integrated, systematic and user-based evaluation approach to help designing learning-centered experiences. However, usability in educational support systems is also affected by contextual factors. Thus, methods that address both the technical and pedagogical dimensions in context of use are still a research issue. These methods will help organizations who want to remain competitive, identify which factors are the most important when adopting technology-supported learning solutions while gradually evolving towards an effective learning process. In this paper, we describe an integrated usability evaluation method empirically tested within an instructional setting in our university. We developed a system prototype to support the internal teaching process and evaluated its role in a technology-supported learning experience. Our results indicate that an e-learning 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 achieve learning effectiveness. While describing ongoing research, we expect that this contribution will provide insights and better understanding on how to evaluate and improve e-learning systems' usability based on learners' 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, e-learning 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's concerns about learning effectiveness and efficiency are driving the search for new ways to approach and evaluate systems' usability in a more situational manner taking into account context's strategic, social and cultural aspects [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 context-, 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 solutions that allow organizations to learn from practice what works best for them in supporting organizational 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 e-learning systems adds new dimensions since courseware delivery methods are not the sole driving concern. Understandability and learnability of a subject are affected by system design, content structure and organization. Therefore, understanding how learners interact with the e-learning systems will contribute to improve the decision-making process, the actions within development teams and the cost-effectiveness of learning. This translates into guidelines on how to improve systems and the instructional process, while influencing the acceptance by learners and enhancing the quality of learning results.

This paper focuses on the interaction between learners and e-learning systems by exploring the people-system fit within an instructional setting. Here, we only explore the usability of e-learning systems and how it affects students' behaviors, 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. We compare perceived ease of use and usefulness of the system in achieving stated learning goals. 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 in order to assist them in the adoption of 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. Consequently, this impairs the role of e-learning as an effective organizational component to achieve expected business goals.

Attempting to optimize the achievement of learning goals, some organizations are getting to e-learning by applying a blended-learning model. Blended-learning combines multiple approaches to pedagogy or teaching. It refers to the integration of e-learning tools with traditional methods to achieve defined learning objectives taking into account learner groups' needs, preferences and capabilities. Interaction with humans in blended-learning experiences is usually supported by synchronous and asynchronous tools, involving e-tutoring alongside face-to-face contacts. By adopting blended-learning solutions, organizations expect to gradually promote cost-effectiveness by: (a) emmeshing learning in their business processes, (b) delivering it on time to the proper target audience, and (c) assertively managing the change process. Work becomes a source of learning contents to be shared among users' performing same tasks or occupying same roles using same system in same context of use. This entails different methods to plan, design and improve learning experiences within changing business environments. Moreover, this demands a high internal fit between business and instructional processes and e-learning systems. In this way, the definition of learning goals and tasks addressing the identified skill gaps are better supported by system functionalities and content is more effectively produced. This work-related and timely just-in-need learning content must be delivered by usable e-learning 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.

As can be seen in Figure 1, e-learning systems reflect institutional decisions to implement specific organizational strategies to skill development. Examples of these are investments in technology, making expert staff av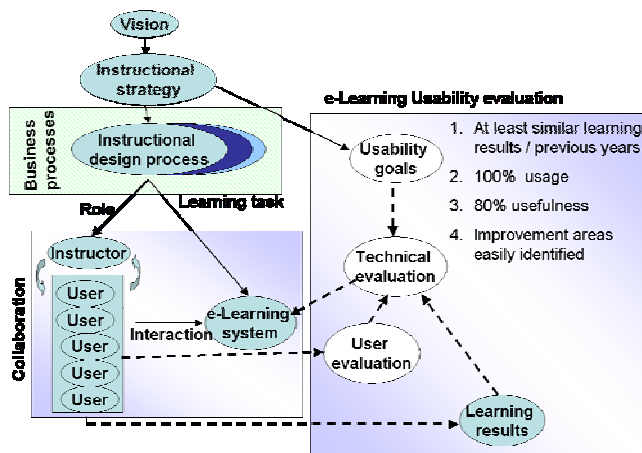ailable to produce content, instructional approaches and methods, facilities, instructor support and also setting high-level system's usability goals. Additionally, instructors' teaching style and context-specific organizational values shape pedagogical methods and contribute to set up the class' sub-culture, 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 usage data against usability and learning goals. This practice will positively influence user acceptance and enhance their sense of control or influence on artifacts surrounding their immediate context of work. In turn, such sense of control will positively affect their behaviors, performance and actions [1] when interacting with instructors and peers via e-learning 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 learners' perspective. Our framework takes into account usability and learning goals and analyzes design-oriented user feedback, inspection evaluation techniques and learning results proposing a specific development kit [13].

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 is 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.

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. This course is part of the Computer Graphics and Multimedia curricula of the Computer Science Engineering Degree at Instituto Superior Técnico in Lisbon. Learning content was structured around theoretical concepts and related examples, and was made available to students through slides (Adobe Acrobat/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
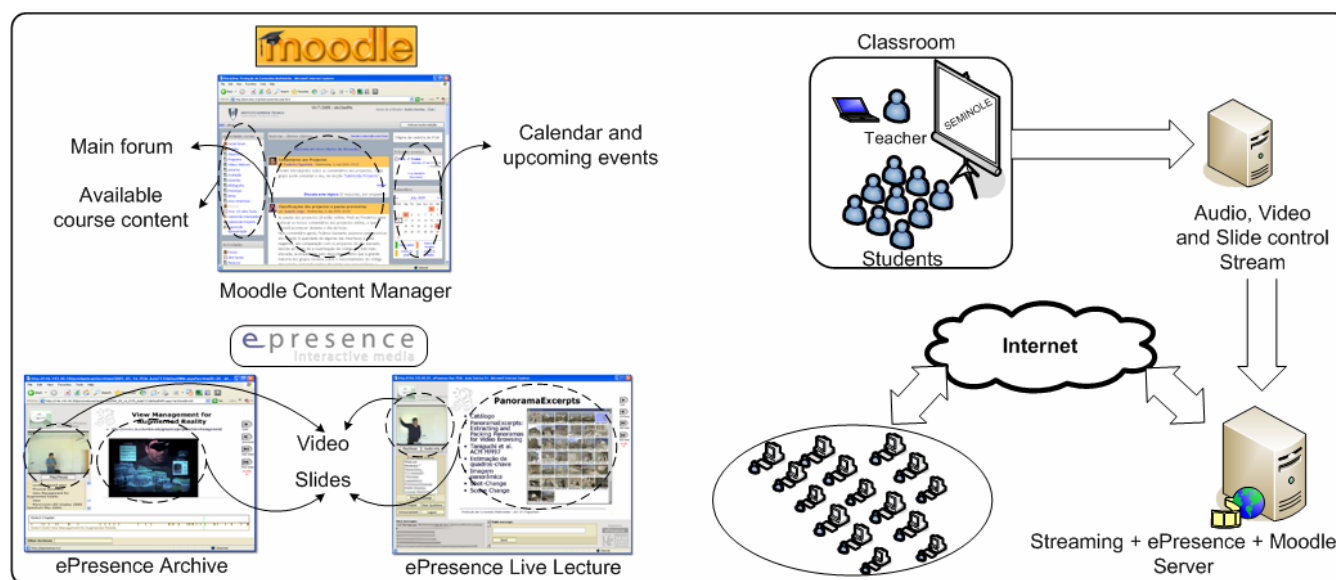

Figure 1 – Conceptual Framework

Figure 2 – SEMINOLE Architecture and Screenshots

were activated. Learners could perform: (a) individual tasks, such as consulting current and archived learning materials, participating in class, fora, project's 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 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 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 is based on an open source LMS, called Moodle [16] integrated with a streaming webcast *and multimedia lesson recording* system (ePresence [17]). The former allows students to access many different contents, participate in online *fora*, take quizzes, check grades, etc. The latter allows webcast and archival of lecture events in a course. In this way, students can attend classes remotely, by viewing slides which are synchronized with audio and video streams. They can also participate in classes, either through chat-room interacting with both teachers and colleagues as well as ask questions to teachers through audio. The internal 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% use it more than 2 hours/day. 82% showed preference to study via Internet when at home. 26% are majoring in Multimedia & Intelligent Systems and 55% major in Information Systems. 73% are 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 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 include collaboration and communication tools, such as fora, chat

and wiki, to deliver consistent messages, better manage existing pedagogical resources, and sustain expected behaviors and perfomance levels. For example, to do the course project, students participated in the respective forum and weekly chat and use 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 matters 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 on a rating scale ranging from 1="Very difficult"; 2="Difficult", 3="Moderately difficult"; 4="Moderately easy"; 5="Easy", 6="Very easy", and (b) how useful were the tasks performed on the system for their learning on a rating scale ranging from 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". 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 dng the same period in SEMINOLE was analyzed to detect usage patterns and monitor established 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.

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. This may be related to the fact that in May learners were more aware of course dynamics and system usage, having formed habits, which minimize the need for this specific information. Though participating in *fora* was perceived as a easy task to perform, its usefulness for learning proc-
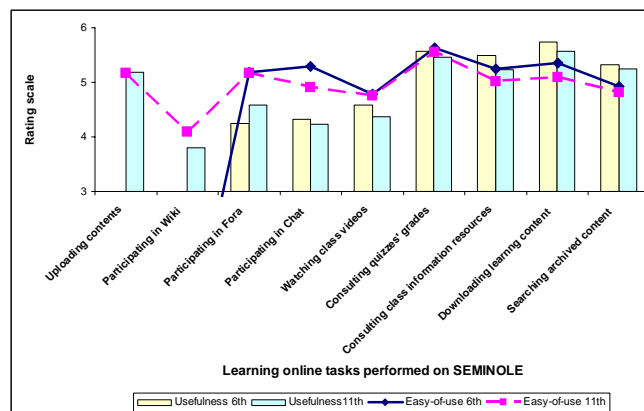

Figure 3 – SEMINOLE Usability

Usefulness response scale: 1=Not useful for me; 2=Very litlle useful for me 3= A litlle 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

ess 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 indicates that individual requirements are 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 is related to 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.
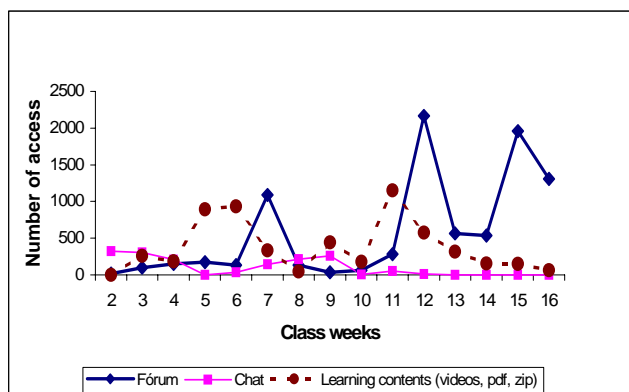
Figure 4 – Total weekly accesses to SEMINOLE

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 relate to reported satisfaction with this blended-learning experience. Figure 5 shows that, 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 reinforces the need for consistency in communicative acts and human support. Grades were the least satisfying of the elements even though more than 90% of students are expected to have a passing grade, and significant changes were detected among the 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 which will be
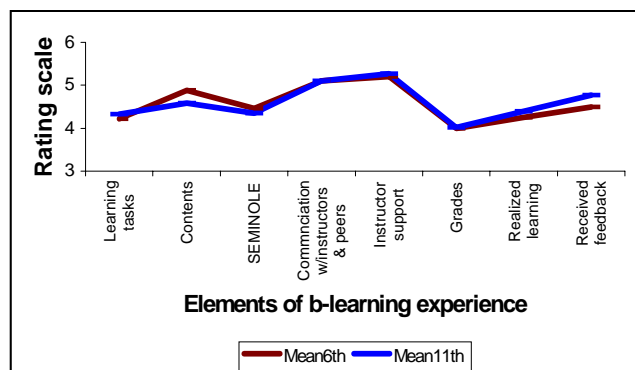
Satisfaction response scale: 1=Totally insatisfied; 2=Insatisfied, 3= Sligtly insatisfied; 4= Silgtly satisfied; 5= Satisfied, 6=Very satisfied

Figure 5 – User satisfaction with MCP Online

deployed in the next version of the system, avoiding interference with the current students' learning process. The most relevant areas are: (a) the navigation scheme and organization of homepage; (b) better multimedia archive navigation interface, (c) communication and collaboration in-built tools (chat, wiki and

fora) to make them more effective tools for learning, (d) further exploration of the effectiveness of web quests in this instructional context, (e) fine-tuned peer-review and grading scheme to enhance students participation in fora, and (f) improvement of content's interactivity and structuring.

Regarding defined learning goals, our results indicate that, at the time of this writing, over 90% of the students are expected to make a passing grade judging by similar patterns at a corresponding time last year. Furthermore, drop-out rate was 1.3% 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 like forum, chat, videos and other learning content were accessed 127000+ times, 86% of which by students, as shown in Figure 4.

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 learners' mental model of the dynamics of technology-supported learning experience. 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 next steps both as a key point to ease the transitional phase towards more advance 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. This observation comes from understanding what users know in context of use to adjust system functioning to perceived (real), rather than postulated user needs.

6. CONCLUSIONS AND FUTURE WORK

As previously mentioned, the goal of this work was to present empirical results from applying our approach to evaluate the usability of an e-learning system within a real instructional setting combining systematic user testing and 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. From doing this, 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 the

technical and pedagogical issues while assessing 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 on user open responses to questionnaires. This would allow the development team to systematically capture and interpret in design terms, what users know about what they do, learn and value as relevant when interacting with human actors and collaborating with them in their context of use. From these data, operational context and user-specific heuristics may emerge to complement design guidelines of e-learning systems. Finally, it would be interesting to apply data mining techniques to detect learning patterns and individual learning strategies in order to improve assertiveness of development teams' decisions and actions when designing more context-specific work-related, easy to use and useful learning tools.

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