WEB-BASED SUPPORT FOR RESOURCE-EFFECTIVE E-LEARNING

M. A. Rentroia-Bonito, Frederico Figueiredo, André Martins, Vitor Fernandes, Joaquim Jorge
e-Learning-in-Organization Research Group, Departamento de Engenharia Informática, IST/INESC-ID, Av. Alves Redol, 9, Lisbon, Portugal

Keywords: e-Learning, Learning Management System, Moodle, Webcast, e-Presence, Customization, SEMINOLE.

Abstract: This article presents work done at the Technical University of Lisbon, on web systems to support technology-enhanced learning. Based on eighteen months experience with webcast technologies and commonly used Learning Management Systems, this work has integrated both concepts and developed a simple, yet effective learning approach. This approach supports both students and professors in moving from the traditional classroom to technology-enhanced online settings. We present the evolution of our system and the results obtained from testing and evaluating the prototype, during the last Spring semester. One of the major features of our approach lies in combining both online and offline components of the e-Learning experience and incorporating desirable traits from traditional and technology-mediated learning. This way, we have identified significant issues for users in order to better manage the changes required to adapt our system to organizational processes and context of use. Our assessment points to changes in the teaching method, course organization, and highlights new factors of students' motivation. Results, however preliminary, seem to indicate both the usefulness of our approach and the feasibility of deploying e-learning initiatives with efforts optimization to complement traditional offerings in university settings.

1 INTRODUCTION

In the past few years there have been substantial advances in e-Learning environments spurned by developments in Communications, Media, and Computing Technologies. However, technology itself is not the single, most important, driving factor in improving e-Learning experiences. As we gain more understanding on the dynamics of online learning, new challenges emerge. Indeed, there is a need for proper methodologies and tools to address these new challenges, as students and educators migrate from traditional classrooms to online environments. This is because both Human Factors and Technology Investments need to be managed in articulation with learning strategies to explore new possibilities in a more resource-effective manner. For courseware developers, this translates into requirements to shorten the development time of courseware that are both cost-effective and acceptable to students. This is challenging work practices in all kind of organizations. The *Instituto Superior Técnico* (IST), of the Technical University of Lisbon, Portugal, is no exception. During the last two years, our research group has been developing an e-Learning system to support the transition of traditional class-room environments to technology enhanced-learning, whether online or offline.

This paper's goal is to share the experimental aspects of our approach to develop, implement, and test an e-Learning solution. We are developing through third-party integration and customization of off-the-shelf components a SEaMless INtegrated Online Learning Environment (SEMINOLE).

The remainder of this paper presents a conceptual overview of our approach and describes our concrete experience at IST. Preliminary assessments and lessons learnt, jointly with potential benefits for each of the main stakeholders, namely instructors, students, system administrators, and educational institutions; and future work are presented. This work aims at setting up a comprehensive framework to analyze online learning and guide development efforts towards resource-effective solutions for e-Learning (Rentroia-Bonito, Tribolet, Jorge & Ghaoui, 2005).

A. Rentroia-Bonito M., Figueiredo F., Martins A., Fernandes V. and Jorge J. (2006).
WEB-BASED SUPPORT FOR RESOURCE-EFFECTIVE E-LEARNING.
In *Proceedings of WEBIST 2006 - Second International Conference on Web Information Systems and Technologies - Society, e-Business and e-Government / e-Learning*, pages 281-286
DOI: 10.5220/0001256702810286

2 CONCEPTUAL FRAMEWORK

Creating and sustaining e-learning settings indicate institutional readiness to assume this new paradigm as part of its strategy, culture, and internal practices. The literature reveals that this readiness covers structural and relationship issues (Dix et al, 1998; Dougiamas & Taylor, 2002; Preece, Rogers & Sharp, 2002; Rosson & Carroll, 2002) and previous works (Rentroia-Bonito, Figueiredo, Martins, Jorge & Ghaoui, 2006b). As shown in Figure 1, as technology gets in the process of learning, the need for structure highly increases and the need for relationship differs.

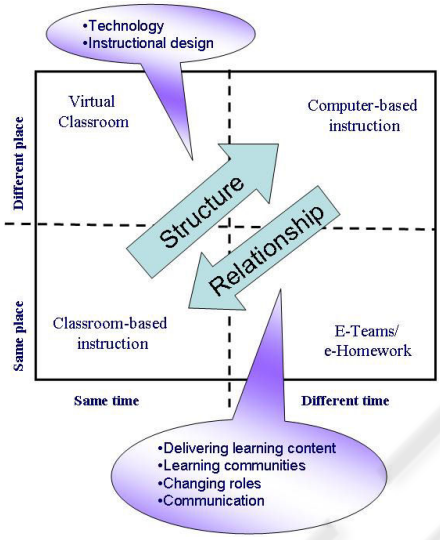

Figure 1: Conceptual Framework.

However, effectiveness and efficacy of this paradigm still relates to how well courseware designers: (a) address the specificities of users' learning needs, characteristics, goals and priorities taking into account their immediate context and available resources; and (b) cover not only the production and distribution of learning content in educational settings, but also its articulation with internal work processes and labour market dynamics and needs.

Technology and instructional design are main issues when structuring an e-learning experience. At this regard, organizational investment in technology (e.g. network, equipment, software), and human resources (e.g. instructors, knowledge or task expert, speakers, helpdesk staff, teachers, and administrative assistants) should meet users' local and remote conditions in order to improve e-learning effectiveness (Rentroia-Bonito, Jorge & Ghaoui, 2006a). Technology should support and explore all four different combinations. Our vision is that a workable technology should address all combinations even if deployed progressively. This involves defining clear milestones in terms organizational acceptance, skill development, required accessibility and infrastructure supporting e-learning experiences to allow for harmonious development.

The following section presents the strategies and progress of our research work with e-Learning at the *Departamento de Engenharia Informática* (DEI) at IST.

3 STRATEGIES AND PROGRESS

After defining an e-learning vision and assuring required resources, the development approach for the solution was iterative and incremental. This first prototype was tested during the Fall semester 2003, giving a e-lecture to 77 HCI students from three Portuguese universities, (Rentroia-Bonito, Jorge & Ghaoui, 2006a). Then, another test was realized during the Spring semester of 2004. Back then, a total of 11 PCM students participated.

This proof-of-concept allows the retrieval of structured and unstructured user feedback that contributes to improve the current understanding of e-learning dynamics reflecting it on prototype requirements and architecture. SEMINOLE was architected during Fall 2004, tested and evaluated during Spring semester 2005 with a class of 28 PCM students. Next, the main development stages until achieving current version of SEMINOLE are presented.

3.1 Stage I: Archive and Webcast

Before this stage was completed, the course was supported by a static Website (PCM, 2004) where contents (announcements, goals, course program, schedules, grading details, delivery dates, and information about the teachers, classifications, and bibliography) were available to all students. All class contents were edited and published manually through the edition of HTML pages and later uploaded to the Website server. In this first stage, we introduced recording and video archiving of all classrooms, and live webcast of invited lectures.

Our first approach consisted of a software tool, supported by FCCN (Portuguese Foundation for Science and Research), that enabled audio and video streaming with support for synchronized presentation slides. These were defined to simulate the classic classroom scenario allowing remote students to interact with other students and the speaker, through the use of email messages and an IRC (Internet Relay Chat) online session. This tool, in its simplicity, had shortcomings related to: (a) high demands for resources (skills, time and media) complex pre and post-production processes, and (b) inefficacies of the integration of IRC session and quizzes evaluation.

In an attempt to get users' feedback, the last live webcast session was evaluated. Based on this user feedback, the alignment between the learning process-system for this user group was improved by implementing a dynamic and more efficient content management tool tightly adapted to the internal teaching process (Rentroia-Bonito, Jorge & Ghaoui, 2006a).

3.2 Stage II: Development of SEMINOLE

The version of the system was designed to meet three main requirements: learning content management, class webcast and archive, and evaluation methods. Its main functionalities were identified based on defined vision, priorities; university's teaching process and analysis of strengths and weaknesses of available Learning Management System (LMS) platforms.

SEMINOLE is based on an opensource LMS integrated with a streaming system, as shown in Figure 2. The former allows students to access all class of contents, participate in online *fora*, take quizzes, check grades, etc. The latter allows webcasting of all events in a course. This way, students can attend classes remotely and view slides which are synchronized with audio and video streams. They can also participate in classes, via chat-room, as well as place questions to teachers and other colleagues.

The learning content management process was tightly supported by a LMS called Moodle (Moodle, 2004) that embraces the social constructivism as an educational philosophy (Dougiamas & Taylor, 2002). Moodle provides the necessary tools for building and managing the course Website (PCM, 2005), facilitating, among others: (a) scheduled delivery of learning content in different formats, (b) possibilities of diverse resources and tasks supporting different learning methods, and (c) fast feedback to students after doing quizzes. For the

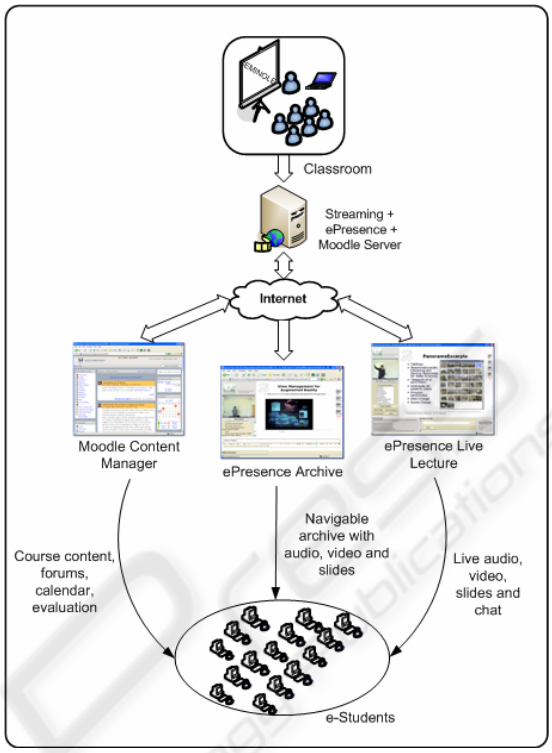

Figure 2: Current SEMINOLE Architecture.

webcast feature, we chose to use ePresence (ePresence, 2004) from KMDI Labs in the University of Toronto, along with additional customization, the component in SEMINOLE currently supports: (a) lectures by audio and video synchronized with slides; (b) integrated and moderated live chat; (c) question submission, and (d) semi-automated generation of structured, navigable, searchable lecture archives.

For students to evaluate the usability of SEMINOLE, online questionnaires were used. Registered students participated in evaluation sessions. Motivation-to-elearn items were captured before students used the system and ten weeks later. The system's usability was evaluated in the last session. Also students reported their system usage frequency and average access duration time. Confidentiality and anonymity were assured before evaluation sessions started. Data was analyzed to identify improvement areas based on results by: (a) comparing motivation-to-elearn perceptions, measured before and after using SEMINOLE; (b) evaluating the usability of the system, and (c) content-analysing responses to open questions.

4 RESULTS AND LESSONS

During this stage four main lessons were identified. First, from technical perspective, several areas of improvement were identified: (a) integrating user logging to allow further analysis of students' access, usage and communication patterns; (b) facilitating content publication by implementing an automated schedule; and (c) taking full advantage of the possibilities of the platform in terms of delivering, and reutilizing, current and archived contents in different formats. This will address the structural and relationship issues shown in Figure 1, improving the alignment between PCM course and SEMINOLE.

Second, structuring e-learning experiences demands strong organization skills from instructors as well as enforcing the application of standard operating procedures. This is required to coordinate efforts from involved staff (e.g. Helpdesk, Content managers and producers, invited speakers, teaching assistants, among others) in order to assure consistent communication during the different events (e.g. posting news, instructions, feedback).

Third, from a class dynamics perspective, learning tasks were facilitated. In particular, communication with local and remote students improved due to the possibility for them to talk to each other. Within webcast sessions, a total of 910 messages were sent, using e-Presence's chat-room feature. 73% of messages were related to communication between the students and the moderator, mainly concerning technical aspects of the session. *Fora* optimized the process of class communication by turning individual answers into collective ones. We also verified that "Course Program", "Evaluation Details" and "How to perform exams (quizzes)" were the most viewed resources, which calls for planning when designing e-learning experiences. For instance, self-reported responses indicated that 58% of students that evaluated SEMINOLE, accessed the system frequently (three or more times per week). 91% of the students reported to have spent less than ten minutes each time they accessed the system, 58% of them took less than five minutes. This raises specific concerns regarding the usability of SEMINOLE. Usability evaluation of the system was done at the 10^{th} week of course by 86% of registered students. Based on system data and user questionnaires, out of 79 posts, 53% were discussions initiated by students. On average, posting was reported as an easy task to perform in the system. Yet, almost 42% of participating students never posted anything. Also, few students reported not to have accessed archived learning content and uploaded materials using SEMINOLE. This translated into specific actions to improve the usability of SEMINOLE's interface.

Fourth, involving students as users into the development cycle, proved to be useful and resource-effective. They were asked to report what they liked the most, the least and what technical and physical conditions must be improved. 45% of responses were given in the first evaluation session. Short-term actions were taken to address some issues (e.g. physical conditions, class rules, site usability, communication issues, among others). Those suggestions that could not be implemented during this semester will be considered for a new version of SEMINOLE (e.g. content organization and structure, improving class dynamics, better user manuals, etc.).

5 EXPECTED BENEFITS

Using our system brought forth several benefits. First, two specific system administration tasks were simplified: (a) edition / re-edition is done directly on the platform, and (b) pre and post-production of webcast classes (live and archive) had their time significantly reduced from one working hour per class hour to about 15 minutes per class.

For instructors, administrative tasks related to quizzes and standard communication instruments (e.g. program, course details, etc.) and events (e.g meeting with students, orientation sessions, etc) are also simplified. This raised other issues, such as the effectiveness of mixing paper-and-pencil and online quizzes, the need for a timely implementation of the course plan and the amount of time required to structure the learning experience once compared with traditional ones. Nevertheless, it is unquestionable that a home-grown and easy-to-use e-learning system, which is also resource-effective to build and maintain, can be a competitive tool to deliver learning content.

For students, the dynamics of e-learning, during SEMINOLE testing, created a "common communication space" for those that actively participated. In this way, online and offline communication reinforce each other, if consistently given. At this regard, frequency of use could be a good indicator of adequate user engagement and participation in online experiences. This will also allow identifying or anticipating specific performance issues and thus setting up the agenda for offline meetings with students, when needed.

For system designers, structured user feedback allowed to concentrate on critical issues negatively affecting engagement and performance (resources and time). Generally speaking, this will likely

improve development time, user acceptance levels and help anticipate major changes in organizational process and required competencies.

For process owners or managers, the results of data analysis (self-reported and coming from system database) will allow obtaining performance metrics. They will be of great value to estimate the usefulness, effectiveness, articulation of results and strategies, return of investment of this kind of initiatives, and support later business-driven decisions. Within current business environment, this will be a useful feature for all kind of organizations to be competitive.

6 FUTURE WORK

As our knowledge of the fundamentals of e-Learning requirements and praxis improves, we expect to derive useful models to assist courseware developers in developing high-quality resource-effective learning materials and interactive courseware. Four areas for future work were identified

First, we believe that collaboration and personalisation are two essential requirements for learning effectiveness. SEMINOLE lacks the ability to: (a) allow students to specify personalization features; (b) promote cooperation and collaboration among students and instructors from local and remote universities, and (c) foster collaborative work among instructors and students In traditional classrooms, students have their own materials available; they chose what to take to a classroom and in what way they want to take notes. Thus, improvements could be added in order to: (a) enhance the feeling of belonging and social presence (Tu, 2002); (b) allow students to specify personalized features, for example, each student could be notified of the archived materials he/she has not yet seen, and (c) enhance the publication workflow. Currently, materials are prepared outside the learning environment, and once they are ready for publication they are added to the archives. Again, as students should be able to share documents and learning materials among themselves, instructors could also be able to create their materials online in a collaborative manner.

Second, from a technological standpoint, SEMINOLE's development will be directed towards two main goals: (a) improving cost-efficiency, and (b) increasing instructor and student immersion/ interactivity. The system's interface and workflow will be simplified by optimizing pre and post-production processes. This way a "one man show" scenario can be possible. Tests with low-cost and highly available hardware have already begun. In these tests, a camera was replaced by a webcam, and the media-encoding server and instructor presentation computer were replaced by a single laptop. Additionally, multimedia content distribution presents several challenges for SEMINOLE: (a) webcast delay, and (b) network bandwidth requirements. To face these challenges, three options were analyzed. Replacing unicast streaming with multicast streaming can reduce bandwidth requirements (Multicast Streaming, 2005), but raises several issues when deployed in a heterogeneous network environment since "a large portion of the Internet is not multicast-enabled" (Yeo, Lee & Er, 2002). Tunneling between multicast-enabled networks (Francis, 2000) potentially solves the bandwidth issue, but the live media delay remains. Research in peer-to-peer content distribution may solve both bandwidth concerns and live content delay. This is based on the principle that interested content receivers will be willing to resend it (Yeo, Lee & Er, 2002; Xu, Xianliang, Mengshu & Chuan, 2005).

Third, planning standardized contents using Sharable Content Object Reference Model (SCORM) for multiple assets, such as presentations, simulations or webcasts, is under way. Also, building basic learning objects from previous raw classes' contents, through the process of standardization, is another step. Then, with sets of basic learning objects, we will develop SCOs (Shareable Content Object). A SCO represents the lowest level of granularity of learning resources that can be tracked by a Learning Management System (LMS) (Advanced Distributed Learning, 2004). Each SCO will have a predetermined sequence and can be seamlessly used for multiple course lessons. Lessons are created from groups of SCOs that can contain a concept, fact, procedure, process or principle (Cisco Systems, 2003). Adding Learning Objects Metadata (LOM) is also planned. LOM makes SCO more reusable, since instructors can search and find them easily. Issues resulting from SCO usage will be analyzed, among them: increasing or decreasing contents granularity; choosing a set of basic learning objects to build a SCO; selecting the right SCOs to build a lesson, and finding an organization or navigation structure.

This approach, using standards like SCORM (or others), brings advantages by making it possible to use materials from different sources into the future standard-compliant SEMINOLE. Changing the learning environment will have no extra costs, beside a new course deployment, because there will be no need to change the SCO itself. This achieves interoperability among user technologies. Standards provide a common data model and by using a standard-compliant SEMINOLE potentially assures

that the course will be correctly delivered, interactions logged and student grades saved. Standards also provide a common packaging format that ensures an easy storage and distribution process. Moreover, building a repository of standardized SCOs is also resource-effective, because reusability increases.

Last, there is a need to rethink business models for effective deploying ee-learning solutions. This is required to develop cost-effective and sustainable approaches to enhance existing curricula through judicious use of IT. This should be the subject of further studies.

7 CONCLUSIONS

We have presented our ongoing work towards a web-based system for supporting resource-effective e-Learning. The main advantages of this solution lie in its cost-effectiveness and just-in-time approach to content production and distribution. We achieved this by using opensource tools and making functionalities available based on user feedback and system data analysis, while trying to respect organizational culture, processes and idiosyncrasies. Usability evaluation results showed that: (a) SEMINOLE is easy to use for the main stakeholders: instructors and students, and (b) e-learning is a team-based process with a complex nature due to its non-linear impact on expected outcomes.

REFERENCES

Advanced Distributed Learning, (2004). Shareable content object reference model (SCORM) 2004 overview. Alexandria, VA: ADL Co-Laboratory.

Cisco Systems, Inc. (2003). Reusable learning object authoring guidelines: How to build modules, lessons and topics. San José, CA: Cisco Systems, Inc.

Dix, A., Finlay, J., Abowd, G., & Beale, R. (1998). *Human-Computer Interaction*. Second edition. Prentice Hall, England.

Dougiamas, M. y P. Taylor (2002) Interpretative analysis of an internet-based course constructed using a new courseware tool called Moodle, en: Goody, A., J. Herrington y M. Northcote (eds.), Proceedings of the 2002 Annual International Conference of the Higher Education Research and Development Society of Australasia (HERDSA) Perth, Western Australia: HERDSA, Inc.

ePresence Interactive Media (2004). Retrieved January 4, 2005 from http://epresence.tv/.

Francis, P (2000), *Yoid: Extending the internet multicast architecture*. Retrieved November 10, 2005 from http://www.icir.org/yoid/docs/

Moodle, Open Source CMS (2004). Retrieved October 17, 2004 from http://moodle.org/.

Multicast Streaming with Windows Media Services 4.1 (2005). Retrieved December 5, 2005, from http://www.microsoft.com/windows/windowsmedia/serve/multiwp.aspx

Preece, J., Rogers, Y. & Sharp, H., (2002). *Interaction Design: Beyond Human-Computer Interaction*. NY: John Wiley & Sons. New York.

PCM - Produção de Conteúdos Multimédia (2004), Lecture course notes (in Portuguese) IST. Retrieved December 5, 2005, from http://immi.inesc-id.pt/pcm04 and http://immi.inesc-id.pt/pcm05.

Rentroia-Bonito, M. A., Tribolet, J.M., Jorge, J. & Ghaoui, C. (2005). Just-in-time approach to virtual learning: Arguing for cost-effective knowledge dissemination in organizations. *Knowledge-Based Virtual Education: User-Centred Paradigms Pt. 1 (Studies in Fuzziness & Soft Computing S.)* In Ghaoui, C.; Jain, M.; Bannore, V.; Jain, L. (Eds.). Berlin: Springer-Verlag and Heidelberg GmbH & Co. K.

Rentroia-Bonito, M. A., Jorge, J. & Ghaoui, C. (2006a). Motivation to e-Learn within organizational settings: An exploratory factor structure, *International Journal of Distance Education Technologies*. In print.

Rentroia-Bonito, M. A., Figueiredo, F., Martins, A., Jorge, J. & Ghaoui, C. (2006b). An Integrated Evaluation Method for e-Learning: A Case Study. International *Journal of Interactive Technologies and Smart Education, Special issue*. In print.

Rosson, M. B. & Carroll., J. (2002). Usability Engineering. Scenario-based Development of Human-Computer Interaction. CA : Morgan Kaufmann Publishers

Tu, C. (2002). The Measurement of Social Presence in an Online Learning Environment. International Journal on E-Learning. 34-45.

Yeo, C.K., Lee, B.S. & Er, M.H. (2002), *A peering architecture for ubiquitous IP multicast streaming*, ACM SIGOPS Operating Systems Review, Volume 36 Issue 3, ACM Press.

Xu, Z., Xianliang, L., Mengshu, H. & Chuan, Z. (2005) A speed-based adaptive dynamic parallel downloading technique, ACM SIGOPS Operating Systems Review, Volume 39 Issue 1, ACM Press.