

<e-aula>: Design and implementation of an e-learning environment based on markup languages and educational standards TIC2001-1462

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Abstract

The main goal of the project is to create an e-learning environment, which will raise e-learning educational standards and will be implemented using the learning community's "de facto" technological standard: the markup language XML. The methodology used to create our application is intended to build a flexible, open and growing enabling environment. A long term goal of the project is to design and implement an e-learning application focused on the learner, which will offer students a flexible application tailored to their educational needs. The three basic objective are to: (1) enable content to be adapted for different student knowledge levels and educational needs; (2) enable content reuse to increase educational quality; (3) to manage the different activities involved in the learning process (such as student information or system use). Our intention is to simplify the management, the interactivity and the usefulness of the educational information distributed over the web.

1 Project context and goals

There is an increasing demand for high quality education adapted to the learner's needs, so that students can obtain maximum benefit from the time spent on their education. This new learning paradigm is usually referred as a "student centred educational model". Nevertheless, despite the new possibilities offered by ICT, some of the old problems of learning systems are still to be overcome, the most remarkable of which are perhaps those of cost effectiveness in the construction of the learning environment, and cost effectiveness of the production and reuse of educational contents [Fernández-Manjón 1997].

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The combination of Internet technologies, new learning design models and usage of markup technologies simplify the construction of learning systems that comprise the “student centered” learning paradigm.

In our opinion there are two main features that will permit an e-learning environment to reach this objective:

1. High quality educational contents. We propose the reutilization of previously existing educational content as a way to increase the quality of courses. Rewriting every course from scratch when there is such a great amount of content already available seems like nonsense: we think that improving mechanisms for reuse will also improve educational quality.
2. Personalized education in three different ways: a) Initial student knowledge; b) Student knowledge objectives, and c) Learning method preferred.

Therefore the main goal of the project is to create an e-learning environment designed and implemented according to two key elements:

1. Use of educational standards at a design level to guarantee platform independence and content reuse. There are several organizations working on technical specifications to reach educational standards at the various layers implied in e-learning applications. Among this initiatives are IMS project [IMS 2003], ARIADNE [ARIADNE 2002], ADL/SCORM [ADL/SCORM 2003], PROMETEUS [PROMETEUS 2003], [Duval 2001].
2. Use of markup technologies (i.e. XML) at a design level to make feasible both content recovery according to different searching criteria and content adaptation to different student educational needs.

Requirements for achieving this objective:

- Design a content oriented methodology to create the system. This allows the environment to be independent of the contents. Adding new contents to the system will be easy, so <e-aula> becomes easily scalable.
- Develop the architecture necessary to create courses based on user profiles. By using educative standards as reference, we will do research on user centred learning.
- Develop different courses and contents. We will try to include courses in different subjects focused on university learning. We will also collaborate with those companies interested in our learning platform.
- Implement different prototypes to evaluate their possibilities in a real environment. Their results will allow us to detect problems and to improve our system. The prototypes will be based on different e-learning standardization proposals.

This project started with the evaluation of two standardization initiatives: IMS and EML. After IMS took on EML and incorporated it as one of its specifications, our two systems merged into a new one implemented under IMS specifications. At the moment, <e-aula> is a prototype to evaluate IMS specifications. We are also developing innovative educational content for testing the capabilities of our e-learning environment with real users (e.g. university students). Thus from the beginning of the project we have been producing computer science pilot courses (e.g. a Java programming course) adapted to the specifics of each application produced (i.e. technical specification and e-learning standard used).

The main innovation of the project is the use of design specifications (educational standards), markup languages and web technologies to develop reusable, flexible and scalable methodologies, contents and environments. Instead of finding particular solutions, we bet on interoperability and reusability. Nowadays, developing educational systems is a very active line of research. There are

no real standards in electronic education, which make it an ideal field for research. Positive results in this area could be far-reaching, not only at a national level but at an international level as well.

2 <e-aula> outcomes

In the development of the <e-aula> system we realized that to reach the initial project objectives (content reuse and content adaptation to assure quality education tailored to student needs), the system and the different information managed, had to reach educational standards. Our opinion is that standardization is the only way to obtain interoperable reusable educational contents. And this is also true for the rest of the information managed by an e-learning system (such as student information, assessment mechanisms, system use, etc).

2.1 First project stage: <e-aula>, e-learning pilot applications.

We then faced a problem: at the time we developed our first pilot application there was no clear agreement about the standards to be used at the various layers implied in an e-learning application. Many organizations had started writing their own specifications and guidelines and these different specifications were often incompatible. Therefore, we readapted our initial project objective to use <e-aula> as a research platform to test and investigate the potential offered by different educational standards. The idea was to implement a number of systems with the basic e-learning infrastructure tools (content creation tools, content recovery tools and content presentation tools) and to use these systems as testing frames to evaluate the e-learning standards potential and their limitations in our fields of interest (basically content reuse and content adaptation).

At a first project stage, we developed two systems to test what we considered the most promising standards at that moment. One of the systems was developed according to IEEE LTSC LOM and IMS specifications. For the metadata layer, the system complied to LOM standard [IEEE LTSC LOM 2001] and for content packaging and course structure layers the specification used was the one developed by the IMS group [IMS CP 2001]. There were three important reasons for choosing this specification group:

1. These are the most accepted and generally implemented specifications in the e-learning community. These specifications are the main base for the most used reference model: ADL/SCORM.
2. They are part of the specifications produced by the IMS group to deal with e-learning systems (such as the “Learner Information Package” [IMS LIP 2001] or “Question and Test Interoperability [IMS QTI 2002], which are also being tested at <e-aula> platform).

The second system that was developed following EML OUNL specification for all the layers involved in the learning object design model [Koper 1999, 2000]. The main reason for choosing EML as the second standard under evaluation for this first project stage, was the educational and pedagogical basis it was based on, which made it more powerful as it offered the perspective of content reuse and adaptation features we were looking for.

These two pilot systems were functional and offered a Java programming course and were initially tested with PhD student (for more information <http://eaula.sip.ucm.es> or <http://eaula2.sip.ucm.es>).

2.2 First project stage conclusions: Standards evaluation in <e-aula>.

From the experiences obtained at this project stage, we reached the following conclusions:

1. The information about content itself offered by the family of standards LOM/IMS is not enough in terms of defining adaptation methods based on a student's level of knowledge, knowledge objectives and learning method preferred. In this sense we feel that it is necessary to reach a deeper granularity level by marking up the content itself. On the other hand, the current specification lacks a pedagogical basis, which may permit defining decision making processes and automatic object sequencing to be defined so that the learning process can be adapted to individual students.
2. EML solution is far richer in terms of the information offered for a single object and for the whole learning process. It is also based on a strong pedagogical theory, which makes the solution a lot more powerful in terms of instructional design. On the other hand, the specification is quite more complex and difficult to implement, which makes the development of content design and content recovery tools harder. It also presents the inconvenience of being incompatible with some other powerful specifications in other aspects of the e-learning process.
3. We consider that a viable solution to overcome the inconveniences found in both specifications would be to combine the simplicity and compatibility with other standards of the IMS specifications group, which the richer content information and pedagogical basis of the EML proposes. In fact, the Learning Design Team at the IMS group is working together with OUNL (EML creators) to reach this combined specification with very promising results analyzed at our next project stage.

2.3 Second Project Stage: Standards Unification.

The initial incompatibility between the two standards we considered the most promising among the different offers available, was overcome quite rapidly. The IMS consortium began a collaboration with the OUNL EML team to develop a unified specification that covered several of the pedagogical deficiencies detected at the <e-aula> first project stage.

At the next stage, the standards offer was quite clearer: the IMS appeared as the most powerful consortium in the standardization arena. To face this new scenario, we decided to unify the two

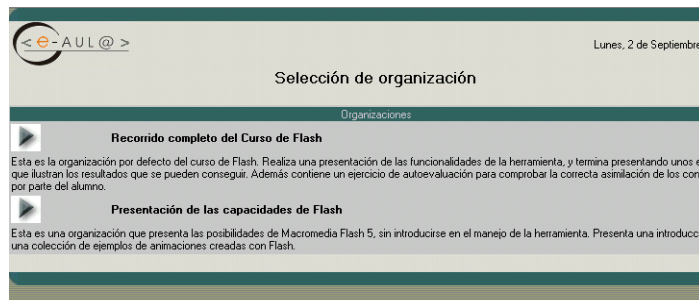


Figure 1. Initial organizations offer. [[<e-aula> 2003](#)]

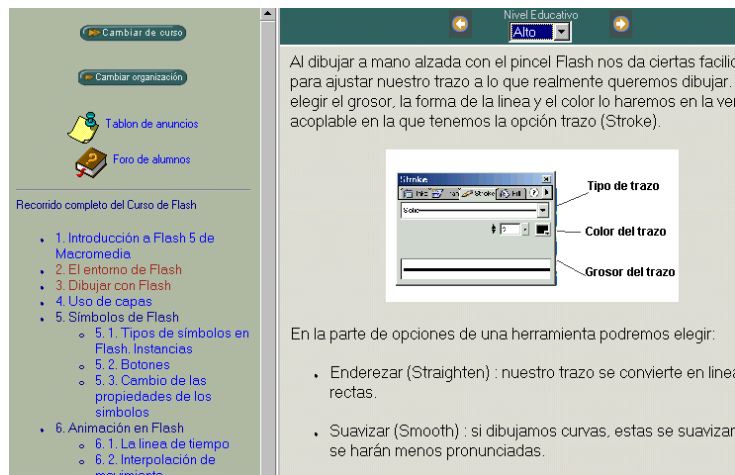


Fig. 2. Information displayed for students with a high level of knowledge.

existing <e-aula> applications and adopt IMS specifications for certain features of our system. We complemented these specifications taking into account ideas from other projects such as: ADL/SCORM, ARIADNE [Forte 1997] and MIT's OKI [OKI 2002].

The underlying objective remains the same as at the previous stage: our intention was to evaluate the potential offered by IMS specifications to enable content reuse and content adaptation.

This new implementation used adaptation capacities offered by this specification at two possible levels:

- Organization level. When accessing the <e-aula> system, the student has the option of choosing between a number of organizations proposed for browsing through the learning contents. This initial organizations offer is made based on the user information available. Figure 3 shows the information displayed when entering one of the <e-aula> courses available (about Macromedia Flash 5).
- Item level. Course creators can define access prerequisites to certain items according to evaluation results obtained by the students, or to previous access to some other items.

In addition to these, we have added a supplementary granularity level: the objects content itself is marked using XML, which provides deeper and more detailed information that can be used for more extended adaptation mechanisms:

Content level of learning objects. The system displays the information contained in one learning object according to the student's level of knowledge (the system has three possible levels: low, medium, high). Although at the moment, the choice is explicitly made by the user picking the difficulty he/she wishes, the next project stage will include student profiling dynamically generated so that the system will display information tailored to the student's profile (see figures 2 and 3).

2.4 Conclusions and Future Work

<e-aula> is a research platform that aims to build a flexible, open and growing enabling environment. To reach this objective, the system has been designed and implemented according to the educational standards. The project has evolved at the same time as the educational standards have: we have used the platform as a tool to investigate the use of learning standards and markup technologies applied to content reuse and personal adaptation in a real learning environment. Aspects such as cost-effectiveness and feasibility of the implementation are priorities of the project.

<e-aula> has been tested not only with PhD students but also with a limited number of third year computer science students at the Complutense University of Madrid as a complement to classroom teaching. We intend to evaluate the main features of the system (such as cost-effectiveness and content adaptation), the results obtained by students and the educational objectives reached.

Some other objectives that we expect to reach at the project stage that is about to begin are:

- Define user modeling process to dynamically display learning objects according to student static and dynamic characteristics [Fernández-Manjón 1998].
- Include a metadata set according to the domain knowledge the learning object is applied to, which will enrich the definition of recovery, reutilization and adaptation processes.

3 <e-aula>: Outcome Indicators

The main result of this project is the collaboration with the Learning Technology Task Force group of the IEEE. The main researcher of this project has been appointed as a liaison member between LITF and WG 3.3 Research on Education Applications of Information Technologies of the IFIP (<http://littf.ieee.org/liaison.htm>).

At this moment we have opened a new line of collaboration with researchers from universities in Germany and Holland to create a group of e-learning named CampusSource lead by Doctor Kaderali of FernUniversität of The Hague. We are considering how to become a network for e-learning excellence in the European Union.

One of the objectives of this project is the study of the state of the art of e-learning technologies and different standardization proposals. This study has produced two technical reports that have been presented in the Departamento de Sistemas Informáticos y Programación of the UCM, and corresponded with the doctoral reports (12 credits) of:

- Pilar Sancho Thomas, Lenguajes de marcado y su aplicación en el dominio de las tecnologías de aprendizaje en la web, UCM, 2002.
- Borja Manero Iglesias, Estudio de la propuesta IMS de estandarización de enseñanza asistida por computadora, UCM, 2003.

With these reports, both researchers obtained the Diploma de Estudios Avanzados and have started their respective doctoral theses under this project environment.

Due to the interest shown by the Universidad Complutense, which is helping us in the developing of quality contents for our system, we are now considering the idea of registering our applications as “modelos de utilidad”. Notice also that Profit S.A. one of the industrial partners initially interested in <e-aula> is now more involved and is providing a student grant to the project.

Next, we include different articles associated to <e-aula> comprising the three working lines comprised in the project, web software development, markup languages and e-learning standardization:

- Fernández-Manjón, B., Fernández-Valmayor, A., Navarro, A., Sierra, J.L. (2002). “Application of XML Mark-up Languages to Software Development”. Upgrade (SIN: 1684-5285), also in Novática (ISSN: 0211-2124). III, 4. **15-20**
- Fernández-Manjón, B., Sancho, P. (April 2002).”Creating Cost-effective Adaptative Educational Hypermedia Based on Markup Technologies and E-Learning Standards”. *Interactive Educational Multimedia*.**1-11**.
- Navarro, A., Fernández-Manjón, B., Fernández-Valmayor, A., Sierra, J.L.(2002) “Formal-Driven Conceptualization and Prototyping of Hypermedia Applications”. Fundamentals Approaches to Software Engineering , ETAPS 2002. **2306, 308-322**. Index of impact (ISI Science - 2001): 0.415
- José Luis Sierra, Alfredo Fernández-Valmayor,Baltasar Fernández-Manjón, Antonio Navarro. (2003). ”Building Applications with Domain-Specific Markup Languages: A Systematic Approach to the Development of XML-Based Software”. Web Engineering. International Conference,ICWE 2003. ISBN: 3-540-40522-4. **2722, 230-240** .Index of impact (ISI Science - 2001): 0.415
- Antonio Navarro, Baltasar Fernández-Manjón, Alfredo Fernández-Valmayor, José Luis Sierra. (2001). “An XML-Based Approach for Fast Prototyping of Web Applications”. International Conference,ICWE 2003. ISBN: 3-540-40522-4. **2722, 241- 244** . Index of

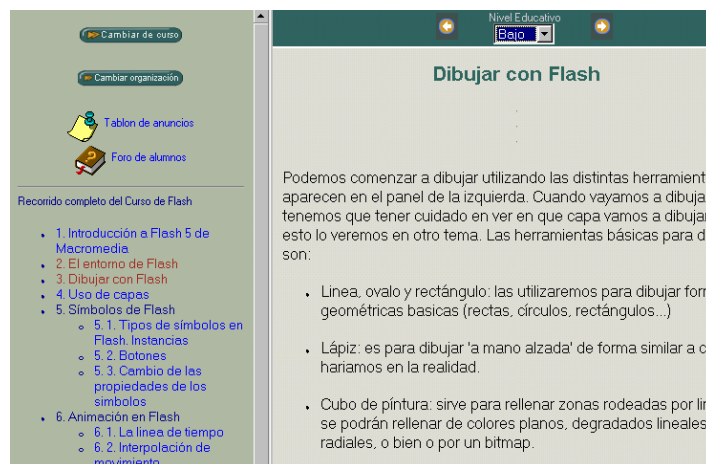


Fig. 3. Information displays for student with low knowledge level.

impact (ISI Science - 2001): 0.415

- José Luis Sierra, Baltasar Fernández-Manjón, Alfredo Fernández-Valmayor, Antonio Navarro (2003). "Aplicación del Paradigma Documental al Desarrollo de Sistemas Basados en el Conocimiento". CAEPIA 2003. <http://polux.lcc.uma.es/CAEPIA2003>. The english version for 'postproceedings' of the conference will be published in Springer-Verlag collection 'Lecture Notes on Computer Science'.
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- Pilar Sancho, Borja Manero Iglesias, Baltasar Fernández-Manjón.(2003). "Usos experimentales de estándares educativos en el sistema <e-aula>". CHALLENGES 2003, III Conferencia Internacional sobre Tecnologías de la Información y la Comunicación en la Educación, realizada conjuntamente con el 5º SIE Simposio Internacional de Informática Educativa, Braga,. **297-304**.

Also, we have new contacts with e-learning researchers at the Universidad de Oviedo, Universidade do Minho (Portugal) and Universidad Autonoma Metropolitana de México (UAM, México). Regarding this last contact, the main researcher of this project was invited to give a plenary conference about this project in the forth Congreso Iberoamericano de Material Didáctico Innovador in Mexico (October 2003).

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