Standard-based Adaptive E-learning Services
(AdaptLearn)
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Abstract

For the last years there has been a proliferation of e-learning tools and resources. This fact, which essentially benefits the learning community, has made it necessary to further elaborate aspects such as authoring, location of suitable learning objects and services, brokerage framework and adaptation of services and resources to the learner and to the learning context. Nowadays and for the past few years, there has been (and there still is) an intense international activity around Learning Technology standardization and interoperability. However, in our opinion, adaptive learning has not been yet adequately addressed in any e-learning specification or standard and requires a further research effort. This project represents a contribution to this task. The main objective of this project is to contribute to the Learning Technology standardization process taking into account adaptability issues regarding both the learning context and the learners themselves. These aspects are addressed using the complementary approaches of the involved groups. On the one hand, Complutense University of Madrid (UCM) will work in the definition and implementation of supporting services for adaptive e-learning (e.g., authoring, integration). On the other hand, the University of Vigo (UV) will work on the provision of a framework with adaptive e-learning advanced services (e.g., location of resources) and its integration with the Digital Administration. It is important to note that several leading e-learning international experts are members of this project team. Their contribution will be focused on the standardization aspects (e.g., early access to new proposals). International experts will also contribute to improve the significance of the outcomes and their applicability to real systems (e.g., .LRN, Moodle).

Keywords: e-learning, adaptability, architectures, methodologies

1 Project objectives

The main objective of this research project was to contribute to the standardization processes in Learning Technology, mainly in terms of adaptation related issues, both regarding the learner needs and the different environments. This objective has been approached by the two participant subprojects from two different and complementary perspectives. On the one hand, the group from the Complutense University of Madrid has focused on the definition of support services (e.g., authoring and integration) for adaptive e-learning environments. On the other hand, the group from University of Vigo has worked in the provision of the intermediation/brokerage systems required to access adaptive content and e-learning services and in the integration of such systems with the Digital Administration. More specifically, the goals of the two aforementioned subprojects were:

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This report has been produced by all the member of the project.
The goals of the UCM (Complutense University of Madrid) subproject were:

- Definition and development of a methodology for language-oriented software development in adaptive e-learning.
- Domain-Specific Languages definition oriented to model highly interactive and user adaptive contents. Proof of concept with real contents.
- Definition of a general framework for the operational support of Educational Modelling Languages (e.g. IMS Learning Design). This framework should be able to cope with the requirements of the adaptive e-learning domain.
- Authoring tools development to facilitate the production of pedagogical designs (e.g. Learning Design, QTI2 2.0) needed in the different adaptive e-learning scenarios. The produced tools will be distributed as open source products.

The goals of the UV (University of Vigo) subproject:

- Definition of an ontological framework to support advanced services for adaptability and brokerage in e-learning.
- Design of a business model and an advanced services brokerage architecture for e-learning with adaptability support.
- Definition of interfaces and interoperability mechanisms between e-learning systems and the digital administration.

To cope with the above defined objectives, the project was divided into four main modules. Each module was developed using an incremental methodology: (1) state-of-the-art, (2) analysis, (3) design, (4) development and (5) testing.

- Module C: Domain-Specific Languages definition oriented to model highly interactive and user adaptive contents. Proof of concept with real contents.
- Module OP: Definition of a general framework for the operational support of Educational Modelling Languages (e.g. IMS Learning Design). This framework should be able to cope with the requirements of the adaptive e-learning domain.
- Module AU: Authoring tools development to facilitate the production of pedagogical designs (e.g. Learning Design) needed in the different adaptive e-learning scenarios. The produced tools will be distributed as open source products.
- Module E: Analysis, supervision and contribution to the standardization process in the e-learning domain.
- Module O: Definition of an ontological framework to support advanced services for adaptability and brokerage in e-learning.
- Module M: Design of a business model and an advanced services brokerage architecture for e-learning with adaptability support.
- Module A: Definition of interfaces and interoperability mechanisms between e-learning systems and the digital administration.

The execution of these tasks has been done in close cooperation between both teams, and the original temporal organization has been followed without significative discrepancies. This collaboration has been also reflected in the technology transfer to enterprises because we are now
working in a shared AVANZA R&D project, called GAME-TEL, where the some outcomes of this project are being used. GAME-TEL is done in cooperation with ATOS Origin, Technosite (enterprise associated to the ONCE Group), CEPAL and Gradiant.

2 Success level achieved in the project

One of the key research areas in this project was the definition of methodologies and languages that would support the design, implementation and application of adaptive e-learning methodologies. We have made significant contributions to the field of language-driven software development, both as a general methodology [2, 11, 12] and in the context of adaptive e-learning [8, 45]. E-learning standards have been a key influence factor in all the project stages and in all the methodologies used. We have tried to develop new products that ease the use of these standards and spread them. The products developed are conceived for users that don't have a deep technical background [24, 39, 56].

A key contribution in this direction has been the development of the <e-LD> subproject. <e-LD> provides operational support for Educational Modeling Languages, and its development has contributed to solve some of the issues identified when applying the EML paradigm [24, 56], in particular, IMS Learning Design. This paradigm is built around the concept of Units of Learning. A Unit of Learning describes all the activities that take place during the learning process. With <e-LD> we try to ease the teacher's task of creating adaptive Units of Learning. <e-LD> provides a graphical tool to author the instructional designs that uses a UML metaphor to abstract IMSLD constructs. At the same time, <e-LD> improves the reusability of the pre-existing designs that are represented in XML [8, 36, 39]. <e-LD> is one of the main contributions of the PhD work carried out by Iván Martínez Ortiz, project member from the UCM group, under the direction of Dr. Baltasar Fernández-Manjón, PI in the UCM group. This PhD thesis has already been completed and will be deposited before the end of the AdaptLearn project.

In terms of content, we have applied our expertise with Domain-Specific Languages and language-driven developments to the study of highly interactive and adaptive content [11], exploring the viability of serious games and simulations as valid media for the delivery of adaptive content [3, 4, 9, 28, 41]. This has resulted in the development of the <e-Adventure> platform, a language-driven tool for the creation of interactive content and its integration in e-learning environments. This tool allows instructors to create highly interactive contents without requiring a programming background, in an attempt to facilitate the introduction of these contents as a component in adaptive e-learning experiences [40, 42]. Moreover interactive contents developed with <e-Adventure> can be packed as Learning Objects following the e-learning standards which allows to automatically deploy that contents in any standard compliant Learning Management System [7, 41]. The development of this project has also yielded contributions in terms of the role these contents should play in adaptive e-learning scenarios, highlighting strengths and limitations in the current standardization efforts in e-learning [41].

We have also worked on user adaptivity in new highly interactive environments such as virtual worlds (e.g. Second Life, Multiverse, etc) in the NUCLEO project. NUCLEO integrates a Virtual World, developed with the Multiverse platform, with a Moodle Learning Management System (LMS). In this framework, we have have applied student modelling procedures taking into a account their learning styles [5, 6, 38, 43]. The adaptation process and the underlying student modelling are aimed at grouping students by complementary learning strategies in order to form effective and semi-autonomous teams. The idea is to ease the teacher's task when conducting the Problem Based Learning strategy that underlies the NUCLEO system [10, 47, 48, 53, 58].
These developments have provided insights of the current state of the different international standardization efforts carried out in the e-learning field. This experience has resulted in an ongoing collaboration agreement between UCM group and the Educational Technologies Institute (ITE previously known as National Centre of Educational Information and Communication CNICE) as experts in e-learning standard technologies, with full access to their educational contents. UCM group have produced two official reports sponsored by the ITE Ministry of Education about “The use of standards in Information and Communication Technologies for Education” [104] and "Standards and Educational Modelling" [105].

Another important outcome from this project is the definition of an ontological framework to support advanced services for adaptability and brokerage in e-learning. In this framework UV has produced the ELEARNING-ONT ontology [85]. The development of ELEARNING-ONT was driven by METHONTOLOGY, a methodology supported by FIPA and selected among a wide set of methodologies analyzed during the early stages of the project (e.g. UPON, On-To-Knowledge, Uschold and King, Grüninger and Fox, Noy and McGuiness, DILIGENT). As a result of the selected methodology a set of models were produced: (1) Specification Model; (2) Conceptualization Model; (3) Formalization Model; (4) Codification Model and (5) Evaluation Model. The eventual ontology is expressed in OWL-2 (Ontology Web Language) while its rules are expressed in SWRL (Semantic Web Rule Language).

The project also provided with the design of a business model and advanced services brokerage architecture for e-learning with adaptability support. The brokerage architecture [61, 80, 95] was developed following the next architectural guidelines: service oriented, interoperability, component-based, MVC, technology independent and functionality distributed among several layers. The eventual architecture was modelled through a structural model, a functional model and a service description. The brokerage model with adaptability support, including both the reference architecture and the ontological model, were the main outcomes of the PhD thesis of Juan Manuel Santos Gago supervised by the PI in the UV group.

In addition to these works, the UV group started a research activity in the field of e-government in the framework of this project. Using the background in the area of Semantic Web and standardization previously applied to e-learning, a PhD thesis was carried out in the area of interoperability, semantic web and digital administration. The key concept here was the provision of a one-stop service [15, 17, 19] where, using semantic web technologies [13], real adaptation to the needs of the citizen was possible. The concept of LifeEvent [18] was introduced as a key element to search for services of actual relevance for the citizen providing thus a citizen-centered system in contrast to previous administration-centered systems. The works in the field of e-government were gathered in the PhD of Luis Álvarez Sabucedo supervised by PI of the UV group.

In addition, there are 4 PhD theses in progress related to this project in the UV group that are expected to be delivered by the end of this project. These works are mainly related to the use of Educational Modelling Languages [21, 22] to support the modelling of adaptive activities and the further development of the adaptive semantic-based brokerage platform [10, 12, 16]. Besides, currently at the UCM group there are 4 Ph.D. theses in progress related to adaptive e-learning, and at least one of them will be presented before the end of this project. These works are providing further insight into the directions that adaptive e-learning will be taken in the near future, which we plan explore further before the end of this project to create the base for a new project proposal. All PhD candidates at the UCM group are enrolled in the official Master “Master de Investigación en Informática” included in the Official Postgraduate Studies “Ingeniería Informática”, which
currently holds the honorary distinction "Mención de Calidad" awarded by the ANECA (reference MCD2006-00500, B.O.E. 30/08/06).

3 Outcomes indicators

Coordination was carried out through four meetings, co-located with AENOR committee CTN71/SC36 in Madrid, with FIE2009 conference in San Antonio (USA) and the Aspect workshop in Vigo (Spain). One of the main activities was the collaboration of the group with the official standardization body for e-learning in Spain: AENOR CTN71/SC36 (working group CTN71/SC36 “Tecnologías de la información para el aprendizaje”) whose main objectives are “Standardization of applications, products, services and specifications related with educational, training or learning technologies in the scope of individuals, organizations or groups, in order to enable interoperability and reuse of tools and resources”.

During the last 3-year project three PhD theses have been completed by project members and supervised by the UCM PI:

- A documental approach to the creation and integration of digital games in virtual learning environments, by Pablo Moreno Ger. 2007. This PhD has the European mention and has obtained two awards as the Best PhD dissertation by IEEE-Education Society-Spanish Chapter and by the UCM Computer Science Studies.
- “Núcleo: Un sistema para el aprendizaje virtual colaborativo escenificado a través de un juego de rol multi-jugador”, by Pilar Sancho Thomas. 2009
- Language engineering techniques for the development of e-learning applications, by Ivan Martínez Ortíz (finished and pending of final public defense). Co-supervisor Dr. Jose Luis Sierra. 2010

In the UV group the 5 PhD theses were produced in the framework of this project:

- Contribution to the improvement of interoperability mechanisms in the framework of digital administration through a semantic approach by Luis Álvarez Sabucedo This PhD has the European mention.
- Contribution to the Brokerage Systems in the framework of e-learning systems using semantic technologies by Juan Manuel Santos Gago awarded by the University of Vigo as the best PhD award.
- Contribution to the Educational Modelling Languages by Manuel Caeiro Rodriguez This PhD has the European mention and has been awarded by the IEEE-Education Society-Spanish Chapter.
- Development of Client-server solutions for Biometric verification of identity and monitoring in web platforms: application in e-learning by Elisardo González Agulla.
- Contribution to the Design of Intelligent Tutoring Systems using Case-based Reasoning by Carolina González Serra

One of the key issues in this project is the use of standards and specifications for learning technologies [14, 20] . The UV group was responsible for the design and development of the official Observatory of the European Committee of Standardization CEN Learning Technologies Standards Observatory (LTSO). Since the beginning of this project, the LTSO has received over 1,1 million visitors with more than 200 news and 300 events published. The LTSO has become the focal access point worldwide for those who want to be aware of the current situation of learning
technologies standardization. Key personnel from both projects are registered in the LTSO as experts in different aspects of e-learning.

From the beginning of the AdaptLearn project the following awards had been obtained: UCM group received 2 Best Paper awards (ICWL2008 [51], GDTW2008 [57]) and 1 Best Paper Finalist (ICWL2009 [41]) and the UV group received the award in the International Symposium on Engineering Education and Educational Technologies.

The <e-Adventure> platform, one of the contributions of this project, is having a great international impact. Since February 2008, when it was originally published, it has received more than 2600 downloads. The platform has been used to develop adaptive educational content in fields such as undergraduate medical education [1], fire safety protocols, international shipping regulations for hazardous materials or creativity and leadership training in corporate environments.

The UCM group has a strong relationship with the industry, the project leader of the UCM group leads or has led more than 7 projects implying technology transfer to the industry. Most of these projects are highly related to the field of e-learning in general and some of them with AdaptLearn in particular. Let us mention the R&D CENIT programme project INREDIS lead by Technosite that is closely related with personalization and accessibility. Other projects from the AVANZA programme are Flexo lead by ATOS Origin and Indra about personal learning in different environments and devices; the previously mentioned GAME-TEL project lead by ATOS Origin and where UCM are the scientific coordinators about the use of serious games in different settings including mobile and IPTV; and finally, eduWAI lead by Germinus XXI (Gesfor) about how to create highly interactive educational contents accessible by all.

The UV group has a high relationship with the industry, the PI of the UV group leads or has leaded contracts for more than 2,8 million euros. Most of these works are highly related to the field of e-learning in general and some of them with this project in particular. Let us mention two contract that the UV group signed with CESGA ("Centro de Supercomputación de Galicia"). The first of these projects: E-PROCURA (Semantic-based brokerage system) [77], aims to deploy in Galicia the very same concepts and outcomes as the ones produced in AdaptLearn, trying to produce a focal access point where all the Galician educational offer can be accessed. The second contract with CESGA, ABC (Competency-Based Learning) will provide, over E-PROCURA, a competency-based search mechanism and a tool for employers to search for potential employees with adequate professional skills.

Both groups UCM and UV are currently involved in the European project CID funded by the Alfa programme, where e-learning standards and specifications are applied to Learning Object standardization and the creation of LO repositories with Latin American countries. UCM group is also involved in the PROACTIVE project from the EU LLP programme about how to use serious games in different educational settings (UCM acts as a technology provider and the <e-Adventure> framework will be used in 4 different countries). Currently, the UCM group is waiting for the final decision on a Network of Excellence proposal about serious games, called GALA, where other 19 European research groups are involved (GALA was preselect and at hearings got first of all NoE at the FP7 IST call 5). The UV group is currently involved in the ASPECT Best Practice Network funded by the eContentPlus programme, where standards and specifications are applied to a critical mass of content provided by a set of European content providers. Currently, the UV group is waiting for final approval of a IP proposal (at hearings, scored 13,5 out of 15, at the FP7 IST call 5) called iTEC. At iTEC the UV group will act as the main technology provider in the field of Semantic technologies.
In the international cooperation with other groups Dr. Pablo Moreno from UCM was invited to visit the MGH Laboratory of Computer Science (affiliated to Harvard Medical School) for six months with the purpose of applying the expertise gathered from the execution of this project in the field of medical education, developing software and training modules for the staff of the Massachusetts General Hospital. We expect this visit to be followed up by visits to the same center by other members of the UCM group. Also UCM group is now working in close cooperation with Macquarie University in Australia to integrate <e-Adventure> as a standard tool in LAMS (Learning Activity Management System) [40, 46]. LAMS is the learning design tool more widespread used in the world and it is integrable in other LMS such as Moodle or BlackBoard.

The UV group is also responsible for the management of the IEEE-Education Society-Spanish Chapter and the Edition of the journal RITA ("Revista Iberoamericana de Tecnologías del Aprendizaje"). Both PIs from UCM group and UV group participate in the Editorial board of this journal. Also Baltasar Fernández-Manjón has been appointed as Associate Editor of the IEEE Transactions on Learning Technology Journal on topics related with this project.

Outcomes from this project have resulted in the following publications (22 JCR-journal papers, 12 non-indexed journal papers, 69 international and national conference papers and book-chapters and 2 official reports). Also both groups have been involved and collaborating in the organization of different relevant international conferences in e-learning such as IEEE ICALT or IEEE EDUCON.

4 References

All the references included below have been the result of different outcomes from this project and may be considered as success indicators.

JCR-Indexed Journals


**Other journals**  
34. Luis Anido, Juan Santos, Rubén Míguez. **Introducción de las TIC en la Educación Infantil de 0 a 3 años.** IE Comunicaciones. Num. 6. pps 3-18. ADIE, 2007. ISSN: 1699-4574.
Book chapters and conferences


39. Iván Martínez-Ortiz, José Luis Sierra, Baltasar Fernández-Manjón: Enhancing IMS LD Units of Learning Comprehension. Article accepted in the 4th International Conference on Internet and Web Applications and Services (ICIW09). May 24-28, 2009, Venice, Italy. 2009


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1 Although all the articles cited here have been produced in the framework of this project, only the most relevant have been cited in the main text of this report.


57. Javier Torrente, Pablo Lavín-Mera, Pablo Moreno-Ger, Baltasar Fernández-Manjón: Coordinating Heterogeneous Game-based Learning Approaches in Online Learning Environments. In Proceedings of the Sixth International Game Design and Technology Workshop and Conference (GDITW2008), pages 27-36. Liverpool, UK. (Received the Best Paper Award from the Program Committee). 2008


60. Manuel Caeiro-Rodríguez, Martín Llamas-Nistal, Luis Anido-Rifón. Components of an EML Proposal for Collaborative Learning Modelling. Computers and Education. Towards Educational Change and Innovation. Edited by António José Mendes,


89. Elisardo González Agulla, Luis Anido Rifón, José Luis Alba Castro, Carmen García Mateo. Is my student at the other side? Applying Biometric Authentication to e-learning environments. Proc. of IEEE International Conference on Advanced


**Official reports**
