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PhD Dissertation Summary: Contributions to the Design, Implementation and Evaluation of Adaptive Learning Management Systems based on standards, which integrate instructional Design with User Modelling based on Machine Learning

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Abstract This paper summarizes the main contributions of the PhD Dissertation with the same title, which focused on adding personalization support in existing learning management systems by considering some artificial intelligence techniques (i.e. user modelling, web usage mining, machine learning, recommendation strategies and human computer interaction). In particular, adaptive navigation support in terms of recommendations was deployed in two learning systems through a web based recommendation service provided by a semantic educational recommender system (SERS) and making an extensive use of standards. Moreover, a user-centred design methodology (i.e. *TORMES*) was defined to design and formatively evaluate educational oriented recommendations.

Keywords: Educational recommender systems, Personalized learning management systems, Adaptive navigation support, User centred design, Standards.

1 Introduction

Learning managements systems (LMS) are widely used in educational institutions to support formal e-learning scenarios [1]. They have been developed, both as proprietary products and as open source initiatives, to provide educational institutions with web based facilities for the teaching/learning processes [2]. However, three main problems can be identified: 1) there is information overload inside LMS [3], 2) LMS does not provide adaptive capabilities to offer personalised and inclusive support to learners through the e-learning life cycle, in spite of the acknowledged need (by diverse national and international reports) of offering a personalised and inclusive support to learners [4, 5, 6], and 3) generic and interoperable solutions based on personalisation and accessibility are still in the research arena [7].

In this context, this Doctoral Thesis offers a solution focused on the individual and changing needs of learners in terms of adaptive navigation support by integrating a recommender system (RS) into LMS in production environments that are based on standards. This proposal is motivated by the success that RS have in other domains where there is also the need to guide users in environments with information overload and inexperience in the alternatives to choose [8].

Taking into account the state of the art in educational RS, there have already been proposals to deploy RS in educational environments. Nevertheless, most of these proposals replicate the approach used in the other domains (e.g. entertainment, e-commerce) and mainly focus on recommending learning objects that have been contributed to complement the instructional design of the course [9]. They do not take into account the particularities of the educational domain in order to design the recommendations, and above all, they do not take advantage of the

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recommendation opportunities offered in the LMS regarding the richness of items to recommend and the diversity of actions to carry on them. In fact, an LMS is not just a learning object repository, but different educational services are provided to support both individual and collaborative learning (e.g. forums, blogs, chats, simulations, etc.). Moreover, learners are supposed to take an active role in their learning, and thus, should also be guided in their contributions to those services. Actually, LMS usually neglect educational issues that can only be managed within the learning scenario, that is, in the instructional design phase of the e-learning life cycle.

Furthermore, building RS for complex functionality challenges the existing evaluation procedures [10] and no systematic evaluation studies of educational RS have been reported in the context of real-life applications [9]. One of the proposals to overcome the inherent complexity of evaluating personalised systems are the layered evaluation approaches, whose idea behind is to decompose the adaptation process and evaluate the system in a "piece-wise" manner [11]. Another open issue is the design of educational oriented recommendations in order to provide the required adaptive support to the learners. For this, the involvement of the educator in the recommendations elicitation process seems valuable [12, 13]. To cope with those open issues, a methodology following user centred design has been proposed, which considers several artificial intelligence techniques.

Thus, the main advantage of the work of this Doctoral Thesis with respect to the current state of the art lies on providing an alternative to deal with the recommendation needs in formal e-learning scenarios and identifying meaningful and useful educational oriented recommendations which can offer a personalised and inclusive support to learners in their individual and changing needs while interacting with a course delivered via an LMS.

2 Contributions

This Doctoral Thesis has produced three main contributions: 1) a new concept of RS in the educational domain, 2) a methodology to design educational oriented recommendations, and 3) two prototypes that provide adaptive navigation support in terms of recommendations for two scenarios with different approaches and requirements.

The **first contribution** is the concept of *SERS* [14]. SERS stand for Semantic Educational Recommender Systems and are characterised by guiding learners -based on some educational criteria- in their interactions with the LMS through personalised and inclusive recommendations that are semantically characterised. The recommendations to be delivered to each learner in her current context are obtained due to the information interchange among the different components involved in the process of generating and delivering recommendations (LMS with tracking capabilities, user model, device model and SERS). Moreover, their performance can be visually analyzed through a set of predefined shapes identified from practice.

SERS depend on the following elements: i) a recommendations model; ii) an open standard-based service oriented architecture, and iii) a graphical user interface. The objective of the *recommendations model* is to semantically characterise the recommendations and bridge the gap between the description of the recommendations done by the educator (including the definition of applicability conditions in terms of available educational specifications) and the logic for delivering recommendations in the course. In this way, learners receive the appropriate recommendations suited to their individual features and current context as well as an explanation about the educational rationale for the recommendation offered. Moreover, this semantic model allows the reasoning about the appropriate recommendations for different situations and facilitates the automation of the recommendations generation process with user modelling based on machine learning. The goal of the *open standard-based service oriented architecture* is to guide the integration of the SERS with existing LMS in an interoperable way by making use of standards to describe the information exchange. In this way, the SERS can offer a recommendation service to the LMS. The aim of the *graphical user interface* integrated in the LMS presentation layer is to show the recommendations delivered to the learners in a usable and accessible way. This graphical user interface is to be used as a reference to integrate the SERS into the corresponding LMS presentation layer and allows describing the recommendation and its features as informed by the recommendations model.

The **second contribution** is a methodology to design recommendations for the SERS called *TORMES* which stands for 'Tutor Oriented Recommendations Modelling for Educational Systems' [15]. Following human computer interaction approaches, this methodology applies user-centred design methods to involve the educator in the elicitation of recommendations that consider educational issues to cover the appropriate instruccional design. In this way, a personalised and inclusive adaptive navigation support can be offered to learners in formal e-learning scenarios. In particular, *TORMES* is an iterative methodology characterised in terms of the following features: 1) influenced by the life cycle of e-learning; 2) based on the user-centred design process defined by ISO 9241-210; 3) combined with web usage mining analysis; 4) applicable for adaptive systems that rely on user modelling based on machine learning; 5) supported by the layered evaluation approach; 6) informed by indicators

and visual representations of the recommendation behaviour; and 7) validated with significance testing over large scale on-line experiments.

The **third contribution** is the development of two prototypes of SERS integrated in two LMS -dotLRN and Willow- which respectively show the flexibility and generality of the *TORMES* methodology when it comes to eliciting recommendations in two scenarios with different approaches and requirements. The *first scenario* is in the context of the course 'Discovering the platform' in dotLRN LMS [16]. In this scenario, 32 recommendations have been identified to support lifelong learning in an accessible way. These recommendations go further than simply recommending learning objects and address issues of interest for personalised and inclusive learning. The *second scenario* is in the context of the course 'Search Strategies in Internet with Educational Goals' in Willow [17]. In this scenario, 12 recommendations have been identified to offer a full e-learning course through a system initially designed for blended learning. The recommendations defined in this second scenario have been formatively evaluated in a large scale experience with nearly 400 students.

3 Conclusions

The approach in this Doctoral Thesis consists in taking advantage of artificial intelligence techniques to extend the adaptive capabilities of existing LMS with adaptive navigation support in order to offer a personalised and inclusive guidance to learners through the e-learning life cycle in formal e-learning scenarios. The key features of the approach are the following: 1) guides learners through the information overload and inexperience of alternatives in the LMS through recommendations; 2) reuses existing infrastructure at educational institutions since it offers a new component (i.e. the SERS) to be integrated with existing LMS in an interoperable way; 3) manages the rich contextual information available in formal e-learning scenarios (i.e. diversity of actions on LMS objects); 4) considers human computer interaction to involve the educator in the process of designing relevant recommendations (with the support of web usage mining) and formatively evaluating their appropriateness for formal e-learning scenarios to take into account instructional design issues (i.e. the *TORMES* methodology); and 5) relies on user modelling based on machine learning to automate the recommendations generation process.

To proof the generality and flexibility of the approach, two existing LMS have been extended with adaptive navigation support to offer a personalised and inclusive guidance to learners through the integration of a SERS whose recommendations have been designed following the *TORMES* methodology. This methodology involves the educator in the recommendations elicitation process through user centred design methods and is influenced by the e-learning life cycle. In this context, the definition of the adaptation features draw on web usage mining. In particular, the following analyses can be carried out: 1) identify troublesome or promising situations, which helps the educator to think of appropriate recommendation needs; 2) tune the design of the recommendations proposed by educators while applying the user centred design methods; and 3) adjust the recommendations design after the course experience.

The proposed approach relies on the availability of the third generation of LMS that are based on a service oriented approach [18] and on the development of specifications and standards that describe the LMS services [2].

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References

[1] Drachsler, H., Bogers, T., Vuorikari, R., Verbert, K., Duval, E., Manouselis, N., Beham, G., Lindstaedt, S., Stern, H., Friedrich, M. and Wolpers, M. Issues and considerations regarding sharable data sets for recommender systems in technology enhanced learning. Proceedings of the 1st Workshop on Recommender Systems for Technology Enhanced Learning (RecSysTEL 2010), p 2849-2858, 2010. doi:10.1016/j.procs.2010.08.010

[2] Muñoz-Merino, P.J., Delgado-Kloos, C. and Fernández-Naranjo, J. Enabling Interoperability for LMS Educational Services. Computer Standards and Interfaces, vol. 31:2, p. 484-498, 2009. 10.1016/j.csi.2008.06.009

[3] Markellou, P., Mousourouli, I., Spiros, S. and Tsakalidis, A. Using semantic web mining technologies for personalised e-learning experiences. Web-Based Education, Grindelwald, Switzerland, p. 461-826, 2005.

[4] European Union eLearning Program (2004-06). Adopting a multi-annual programme (2004-2006) for the effective integration of Information and Communication Technologies (ICT) in education and training systems in Europe, 2004. Available at http://europa.eu.int/comm/education/programmes/elearning/doc/dec_en.pdf.

[5] Hauger, D. and Kock, M. State of the Art of Adaptivity in E-Learning Platforms. Workshop at Adaptivity and User Modeling in Interactive Systems ABIS 2007, Halle/Salle, Germany, 2007.

[6] Moreno, G., Martinez-Normand, L., Boticario, J.G. and Fabregat, R. Research on Standards Supporting A2UN@: Adaptation and Accessibility for ALL in Higher Education. In Proceedings of the Third Workshop Towards User Modeling and Adaptive Systems for All (TUMAS-A 2009): Modeling and Evaluation of Accessible Intelligent Learning Systems, p. 1-10, 2009.

[7] Seale, J. and Cooper, M. E-learning and accessibility: An exploration of the potential role of generic pedagogical tools. In Computers and Education, Vol. 54, Issue 4, 2010, p. 1107-1116. doi:10.1016/j.compedu.2009.10.017

[8] Schafer, J.B., Konstan, J.A., Riedl, J. E-commerce recommendation applications. Data Mining and Knowledge Discovery, 5, p. 115-152, 2001.

[9] Manouselis, N., Drachsler, H., Vuorikari, R., Hummel, H. and Koper, R. Recommender Systems in Technology Enhanced Learning. In Kantor P., Ricci F., Rokach L., Shapira, B. (Eds.), Recommender Systems Handbook: A Complete Guide for Research Scientists and Practitioners, p 387-415, 2010. doi: 10.1007/978-0-387-85820-3

[10] Zins, A. H., Bauernfeind, U., Del Missier, F., Mitsche, N., Ricci, F., Rumetshofer, H. and Schaumlechner, E. Prototype Testing for a Destination Recommender System: Steps, Procedures and Implications. In: Frew, A. J. (ed.): Information and Communication Technologies in Tourism (ENTER 2004). Proceedings of the International Conference in Cairo, Egypt, Springer, Vienna-New York, p. 249-258, 2004.

[11] Paramythis, A., Weibelzahl, S. and Masthoff, J. Layered evaluation of interactive adaptive systems: framework and formative methods. User Modeling and User-Adapted Interaction, Vol 20, 383–453, 2010. doi: 10.1007/s11257-010-9082-4

[12] Al-Hamad, A., Yaacob, N. and Al-Zoubi, A.Y. Integrating 'Learning Style' Information into Personalised e-Learning System. IEEE Multidisciplinary Engineering Education Magazine, vol. 3, no. 1, 2008.

[13] Shen, L. and Shen, R. Learning Content Recommendation Service Based-On Simple Sequencing Specification. ICWL 2004, p. 363-370, 2004.

[14] Santos O.C., Boticario J.G. Requirements for Semantic Educational Recommender Systems in Formal E-Learning Scenarios. Algorithms. 2011; 4(2):131-154. doi:10.3390/a4030131

[15] Santos, O.C.; Boticario, J.G. TORMES methodology to elicit educational oriented recommendations. Lect. Notes Artif. Intell. 2011, 6738, 541–543, 2011. doi:10.1007/978-3-642-21869-9_95

[16] Santos, O.C.; Boticario, J.G. Modeling Recommendations for the Educational Domain. In Proceedings of the 1st Workshop Recommender Systems for Technology Enhanced Learning (RecSysTEL 2010), Barcelona, Spain, 29–30 September 2010; pp. 2793–2800, 2010. doi:10.1016/j.procs.2010.08.004

[17] Pascual-Nieto, I.; Santos, O.C.; Perez-Marin, D.; Boticario, J.G. Extending Computer Assisted Assessment systems with Natural Language Processing, User Modeling, and Recommendations based on Human Computer Interaction and Data Mining. In Proceedings of the International Joint Conference on Artificial Intelligence, Barcelona, Spain, 19–22 July 2011; pp. 2519–2524, 2011.

[18] Dagger, D., O'Connor, A., Lawless, S., Walsh, E. and Wade, V.P. Service-oriented e-learning platforms. From Monolithic systems to flexible services. IEEE Internet Computing, May-June, p. 28-35, 2007. doi: 10.1109/MIC.2007.70