AIED 2009: 14th International Conference on Artificial Intelligence in Education

Workshops Proceedings

Editors and Co-Chairs:

Scotty D. Craig
University of Memphis, USA

Darina Dicheva
Winston-Salem State University, USA

July 6-7th, 2009
Brighton, UK

Preface

The supplementary proceedings of the workshops held in conjunction with AIED 2009, the fourteen International Conference on Artificial Intelligence in Education, July 6-7, 2009, Brighton, UK, are organized as a set of volumes - a separate one for each workshop.

The set contains the proceedings of the following workshops:

- **Volume 1: The 2nd Workshop on Question Generation**
  Co-chairs: Vasile Rus & James Lester. *University of Memphis, USA & North Carolina State University, USA.*
  http://www.questiongeneration.org/AIED2009/

- **Volume 2: SWEL'09: Ontologies and Social Semantic Web for Intelligent Educational Systems**
  Co-chairs: Niels Pinkwart, Darina Dicheva & Riichiro Mizoguchi. *Clausthal University of Technology, Germany; Winston-Salem State University, USA & University of Osaka, Japan.*
  http://compsci.wssu.edu/iis/swel/SWEL09/index.html

- **Volume 3: Intelligent Educational Games**
  Co-chairs: H. Chad Lane, Amy Ogan & Valerie Shute. *University of Southern California, USA; Carnegie Mellon University, USA & Florida State University, USA.*
  http://projects.ict.usc.edu/aied09-edgames/

- **Volume 4: Scalability Issues in AIED**
  Co-chairs: Lewis Johnson & Kurt VanLehn. *Alelo, Inc., USA & Arizona State University, USA.*
  http://alelo.com/aied2009/workshop.html

- **Volume 5: Closing the Affective Loop in Intelligent Learning Environments**
  Co-chairs: Cristina Conati & Antonija Mitrovic. *University of British Columbia, Canada & University of Canterbury, New Zealand.*
  http://aspire.cosc.canterbury.ac.nz/AffectLoop.html

- **Volume 6: Second Workshop on Culturally-Aware Tutoring Systems (CATS2009): Socio-Cultural Issues in Artificial Intelligence in Education**
  Co-chairs: Emmanuel G. Blanchard, H. Chad Lane & Danièle Allard. *McGill University, Canada; University of Southern California, USA & Dalhousie University, Canada.*
  http://www.iro.umontreal.ca/~blanchae/CATS2009/

- **Volume 7: Enabling Creative Learning Design: How HCI, User Modelling and Human Factors Help**
  Co-chairs: George Magoulas, Diana Laurillard, Kyparisia Papanikolaou & Maria Grigoriadou. *Birkbeck College, University of London, UK; Institute of Education, UK; School of Pedagogical and Technological Education, Athens, Greece & University of Athens, Greece.*
  https://sites.google.com/a/lkl.ac.uk/learning-design-workshop/Home

- **Volume 8: Towards User Modeling and Adaptive Systems for All (TUMAS-A 2009): Modeling and Evaluation of Accessible Intelligent Learning Systems**
  Co-chairs: Olga C. Santos, Jesus G. Boticario, Jorge Couchet, Ramon Fabregat, Silvia Baldiris & German Moreno. *Spanish National University for Distance Education, Spain & Universitat de Girona, Spain***.**
  https://adenu.ia.uned.es/web/es/projects/tumas-a/2009

- **Volume 9: Intelligent Support for Exploratory Environments (ISEE'09)**
  Co-chairs: Manolis Mavrikis, Sergio Gutierrez-Santos & Paul Mulholland. *London Knowledge Lab, Institute of Education/Birkbeck College, University of London, UK & Knowledge Media Institute and Centre for Research in Computing, The Open University, UK.*
  http://link.lkl.ac.uk/isee-aied09

- **Volume 10: Natural Language Processing in Support of Learning: Metrics, Feedback and Connectivity**
  Co-chairs: Philippe Dessus, Stefan Trausan-Matu, Peter van Rosmalen & Fridolin Wild. *Grenoble University, France; Politehnica University of Bucharest; Open University of the Netherlands & Vienna University of Economics and Business Administration, Austria*.
  http://webu2.upmf-grenoble.fr/sciedu/nlpsl/

While the main conference program presents an overview of the latest mature work in the field, the AIED2009 workshops are designed to provide an opportunity for in-depth discussion of current and emerging topics of interest to the AIED community. The workshops are intended to provide an informal interactive setting for participants to address current technical and research issues related to the area of Artificial Intelligence in Education and to present, discuss, and explore their new ideas and work in progress.

All workshop papers have been reviewed by committees of leading international researchers. We would like to thank each of the workshop organizers, including the program committees and additional reviewers for their efforts in the preparation and organization of the workshops.

July, 2009
Scotty D. Craig and Darina Dicheva

AIED 2009 Workshops Proceedings
Volume 8

Towards User Modeling and Adaptive Systems for All: Modeling and Evaluation of Accessible Intelligent Learning Systems (TUMAS-A 2009)

Workshop Co-Chairs:

Olga C. Santos, Jesus G. Boticario, Jorge Couchet
aDeNu Research Group, UNED, Spain

Ramon Fabregat, Silvia Baldiris, German Moreno
Institute of Informatics & Aplications, Universitat de Girona, Spain

https://adenu.ia.uned.es/web/es/projects/tumas-a/2009

Preface

There is a growing interest in providing technology-mediated lifelong learning services for all. Although an increasing number of the users interested in these services are adult learners and people with disabilities most available settings do not consider accessibility requirements. The lifelong learning paradigm recognizes that, in a knowledge based society, education and work are integrated throughout people's lives. In this context, technology is expected to attend the learning needs of the students in a personalized way. This paradigm features specific open issues that cannot be addressed by the mere application of other related field solutions. Thus, it is a hot research issue how to build and evaluate learning systems that adapt to the user needs and consider their functional diversity so that their accessibility needs are met.

TUMAS-A is a series of workshops aimed at fostering the research in learning environments that provide a personalized, accessible and ubiquitous support for their users using the appropriate technologies and standards. To accomplish these research goals from a multi-disciplinary approach, the TUMAS-A workshops are being organized in conjunction with relevant conferences from different but related fields. For this third edition, we considered that AIED community is an appropriate audience to obtain new insights on knowledge representation for learning systems that care for all users. The following topics from the main conference were proposed to be discussed in the workshop from the TUMAS-A perspective: 1) Modeling and Representation, 2) Learning Contexts and Domains, 3) Intelligent Technologies, and 4) Evaluation. The submissions received covered diverse issues from the above topics, such as adapting AIED tools, eLearning challenges for independent life, ontologies, models and standards to support personalized eLearning, analysis of interaction traces to feed adaptation with artificial intelligence techniques, and methodologies for evaluating accessible adaptable eLearning platforms based on competences.

The workshop is traditionally organized following the Learning Café methodology, which has been successfully proven at the past editions. The issues posed by the participants in their submissions are used as the starting point for interactive group discussions as established by the methodology.

Workshop organizers expect a wide participation from the AIED community.

July, 2009
Olga C. Santos, Jesus G. Boticario, Jorge Couchet,
Ramon Fabregat, Silvia Baldiris & German Moreno.

Program Committee

Co-Chair: Olga C. Santos, *aDeNu Group, UNED, Spain* (ocsantos@dia.uned.es)
Co-Chair: Jesus G. Boticario, *aDeNu Group, UNED, Spain* (jgb@dia.uned.es)
Co-Chair: Jorge Couchet, *aDeNu Group, UNED, Spain* (jcouchet@dia.uned.es)
Co-Chair: Ramon Fabregat, *University of Girona, Spain* (ramon@silver.udg.edu)
Co-Chair: Silvia Baldiris, *University of Girona, Spain* (baldiris@silver.udg.edu)
Co-Chair: German Moreno, *University of Girona, Spain* (gmoreno@silver.udg.edu)

Bert Bredeweg, *University of Ámsterdam, Netherlands*
Rafael Calvo, *University of Sydney, Australia*
Rosa Carro, *Universidad Autonoma de Madrid, Spain*
Ricardo Conejo, *Universidad de Málaga, Spain*
Martyn Cooper, *Open University, UK*
Emmanuelle Gutierrez y Restrepo, *SIDAR Foundation, Spain*
Judy Kay, *University of Sydney, Australia*
Angeles Manjarres, *UNED, Spain*
Loic Martinez, *Universidad Politécnica de Madrid, Spain*
Yehya Mohamad, *FIT, Germany*
James Ohene-Djan, *University of London, UK*
Helen Petrie, *University of York, UK*
Christopher Power, *University of York, UK*
Alejandro Rodriguez-Ascaso, *UNED, Spain*
Carlos Velasco, *FIT, Germany*

Table of Contents

Research on standards supporting A2UN@: Adaptation and Accessibility for ALL in Higher Education

German MORENO[a], Loïc MARTINEZ[b], Jesus G. BOTICARIO[c], Ramón FABREGAT[a]

[a] *Institute of Informatics and Applications (IIiA), Universitat de Girona, Spain*
gmoreno@eia.udg.edu, ramon.fabregat@udg.edu
[b] *DLSIIS Facultad de Informática, Universidad Politécnica de Madrid.*
loic@fi.upm.es
[c] *aDeNu Research Group, Artificial Intelligence Department, Computer Science School,UNED*
jgb@dia.uned.es

Abstract. Currently there are many standards that impinge on accessibility issues regarding users' models, learning scenarios, interaction preferences, devices capabilities, metadata for specifying the delivery of any resource to meet users' needs, and software accessibility and usability. Each standard represents a different viewpoint with its own sets of goals and scope and it is difficult to understand the existing relationships between them. This paper gives an overview on the existing standards addressing accessibility, usability and adaptation issues in e-learning, and discusses their application to cope with the objectives of the A2UN@ project, which focuses on attending the accessibility and adaptation needs for ALL in Higher Education.

Keywords. Adaptation, Accessibility, e-Learning, Standards

Introduction

Higher education should be an accessible service to all to consider the specific needs of each student and to adapt their processes based on the context, environment, devices, competences, skills and individual abilities. Perhaps the above sounds utopian, but the truth is that it has begun to be realized. This statement comes from a state of consciousness of mankind in the problem of exclusion of some people to access, because of their disability, to information, services, products and places, the use of which was intended to be global in nature [1], and it reaffirms, when the efforts of universities, governments, standards bodies, corporations, foundations and non-profit organizations, are able to state that the term "accessibility" should be included in any human-oriented project [2].

Higher Education (HE) in the form of distance education on the Internet (e-learning) is one of the most promising and important solutions for addressing this problem (for instance, in Spain roughly 50% of students with disabilities choose the distance learning mode [3]). On the other hand, the Information and Communications Technologies (ICT) play today an increasingly important role at HE supporting the e-learning process of students and professionals with specific needs, including those who have so-called disabilities. However, ICT used in e-learning are still not fully accessible for all. For this reason, European initiatives as well as national legislations promote and regulate actions to enable the conditions for everyone to take part in the information society by providing both, “services, procedures, and information in an accessible way for every person”, and policies to create a society that is ready to technological changes in the time they occur. This is strongly related to de concept of life-long learning (LLL), that can be defined as the lifelong, lifewide, voluntary, and self-motivated pursuit of knowledge for either personal or professional reasons [4]. Accessibility is extremely relevant for the LLL paradigm, due to the evolution of human capabilities when ageing.

A2UN@ is a research project whose main objective is to analyze the possibility of developing a general ICT framework, which will be based on standards and user modelling, to support the development of the LLL services required to attend the accessibility and adaptation needs for ALL in Higher Education, with special attention to the diversity of requirements of adult and disabled learners.

This paper reflects the first results of an analysis of standards related to accessibility, usability and adaptability of e-learning in the context of the A2UN@ project. The next section provides a brief introduction to the aims and scope of A2UN@, with special attention to strategy of using standards. Section 2 provides a list of standards that are considered relevant to the project. Finally, section 3 discusses about the possibility of creating a standards based generic LLL model.

1. A2UN@: Accessibility and Adaptation for ALL in Higher Education

The project A2UN@ “Accessibility and Adaptation for ALL in Higher Education”, is funded by the Spanish Ministry of Science and Innovation. It began on January 2009 and will last for 3 years. The project involves the National University of Distance Education (UNED) and the University of Girona (UdG), the UNED coordinates the project.

Its main goal is to build a general ICT framework to support the development of the LLL services required to attend the accessibility and adaptation needs for ALL in HE. To this end, the project has been structured through a series of work packages, including following areas: (1) standards supporting IT accessibility to learning objects and services, (2) user modelling and dynamic support, (3) adaptive and re-usable learning services and workflows, and (4) device modelling, adaptive user interfaces and negotiation strategies. Thus, the goal of this project is to detect, extend, interrelate, integrate and exploit as much as possible all these areas upon which a general, flexible, open, standard-based framework can be defined to support the development of the LLL paradigm.

The driving need to achieve interoperability at different levels of abstraction is the “wide variety of services, contents and devices in large information systems”. This need is another challenge: to develop the required interoperable and layer-based infrastructure to facilitate the definition, development, deployment and evaluation of the services to be provided for supporting accessible and personalized learning in HE.

A2UN@ follows a strategy of active use of standards with the purpose of development his objectives. The open question is, “can international standards, in a dynamic global environment, meet the challenges of modern society, such as the implementation of LLL?”. Our initial hypothesis is affirmative and is based on two premises:

1. *Widespread use:* to ensure the success of a product, service or technology, it should be accepted, implemented and used by a large majority of people which it benefits. We believe that the use of international standards is an appropriate way to gather knowledge about a given topic with a sufficient level of representation of stakeholders.
2. *Starting point*: we intend not to reinvent the wheel. The use of standards is a good starting point for verifying and analyzing the knowledge gathered so far on a specific issue, and from this to try and improve it as much as possible.

Moreover, we believe that knowledge about a subject is dynamic and must be appropriate to the needs of mankind. Therefore, another objective of the project A2UN@ is to work actively in the extension and evolution of standards to reflect new findings [5].

2. Relevant standards for A2UN@

Here we present the first results of the analysis of standards that could support the development of A2UN@. We have structured this description into two sub-sections, the first one provides an overview of the chosen standards and criteria for their selection and the second one presents the analysis itself.

We have used as key sources of information the report on accessibility-related standards by Richard Hodgkinson for the Royal National Institute for de Blind [6], and the standards inventory in ISO/IEC FDTR 29138-2 [7].

2.1. Overview of standards

The choice of the following standards[1] has met the following criteria:

- They address some of the research areas covered by A2UN@.
- They are international guidelines or standards.
- They have a special emphasis on addressing accessibility and usability.

2.1.1. ETSI EG 202 116 V1.2.1 - design for all guidelines for ICT products and services [8]

This document gives guidance to ICT product and service designers on human factors issues; good human factors design practice, and relevant international and national standards. The guidelines are intended to encourage a "Design for All" approach so as to make products and services accessible to as many people as possible, including elderly people and persons with disabilities, without the need for adaptation or

[1] The standards are presented in alphabetical order according to their complete code.

specialized design. This document is applicable to ICT products with a user interface that are connectable to all kinds of fixed and mobile telecommunications networks.

2.1.2. ETSI draft ES 202 746 - User profile preferences and information [9]

This upcoming standard defines a set of user profile preference and information settings for deployment in ICT services and devices for use by ICT users and suppliers. The present document specifies: (a) objects including settings, values, operations and a lexicon of end user terms; (b) a rule definition language for defining functionality such as automatic modification of profiles.

Profile solutions within the scope of the present document are: (1) those provided for the primary benefit of the end-user; (2) those which the end-user has rights to manage the profile contents; (3) those where the end-user has the right to have a dialogue with the information owning stakeholder.

2.1.3. IEEE std. 1484.12.1-2002 - learning object metadata [10]

It is a multipart standard that specifies learning object metadata (LOM). In this standard a metadata instance for a learning object describes relevant characteristics of the object to which it applies. Such characteristics may be grouped in several categories: general, life-cycle, meta-metadata, educational, technical, rights, relation, annotation and classification.

2.1.4. IMS Learner Information Package Accessibility for LIP (IMS AccLIP) [11]

The Accessibility for LIP (Learning Information Package) defines two new sub-schemas for IMS LIP [12]. These two sub-schemas provide a means to specify accessibility preferences and learner accommodations. These preferences go beyond support for people with disabilities to include kinds of accessibility needs such as mobile computing, noisy environments, etc.

2.1.5. IMS AccessForAll Meta-data Specification (IMS AccMD)[13]

The AccessForAll Meta-data specification is intended to make it possible to identify resources that match a user's stated preferences or needs. These preferences or needs would be declared using the IMS Learner Information Package Accessibility for LIP specification. The needs and preferences addressed include alternative presentations of resources, alternative methods of controlling resources, alternative equivalents to the resources themselves and enhancements or supports required by the user. The specification provides a common language for identifying and describing the primary or default resource and equivalent alternatives for that resource.

2.1.6. IMS Guidelines for Developing Accessible Learning Applications (IMS GDALA) [14]

This specification provides a framework for the distributed learning community. This framework set the stage for what solutions exist, what the opportunities and possibilities are for implementing them, and the areas where more development and innovation are still needed in educational technologies to ensure education that is truly accessible to anyone, anytime, anywhere.

2.1.7. ISO 9241-110 - dialogue principles for human-system interaction [15]

This standard sets forth ergonomic design principles formulated in general terms (i.e. presented without reference to situations of use, application, environment or technology) and provides a framework for applying those principles to the analysis, design and evaluation of interactive systems. The principles are: suitability for the task, self-descriptiveness, conformity with user expectations, suitability for learning, controllability, error tolerance and suitability for individualization.

2.1.8. ISO 9241-129 - Guidance on software individualization [16]

This upcoming standard will contain ergonomic requirements and recommendations for software-based individualization of human-computer interactions. There are a variety of different basic individualization mechanisms, each of which can have different positive and negative effects on users. Individualization can result from customization (initiated intentionally by the user) and/or adaptation (initiated by the system). Individualization can result in a variety of changes to the user interface, depending on the particular individualization mechanisms involved. This standard will include guidance on:

1. determining where individualization is appropriate
2. selecting appropriate types of individualization mechanisms
3. using all types of individualization mechanisms
4. using specific types of individualization mechanisms
5. using combinations of different types of individualization mechanisms.

2.1.9. ISO 9241-151 – guidance on web user interfaces [17]

This standard provides recommendations and guidelines for the human-centred design of Web user interfaces to increase their usability. The standard is focused on four aspects of designing Web user interfaces: high-level design decisions and design strategy; content design; navigation and search; content presentation.

2.1.10. ISO 9241-171- guidance on software accessibility [18]

This standard provides requirements and recommendations for the design of accessible software. It is applicable to the accessibility of interactive systems and it addresses a wide range of software (e.g. office, web, learning support and library systems).

It promotes increased usability of systems for a wider range of users. While it does not cover the behaviour or requirements for assistive technologies (including assistive software), it addresses the use of assistive technologies as an integrated component of interactive systems.

2.1.11. ISO 9241-20 - accessibility guidelines for information/communication technology (ICT) equipment and services [19]

This standard provides general recommendations to improve the accessibility of ICT equipment and services. This document is intended to be used as a source for defining technology-specific requirements when designing accessible products. If a specific detailed standard exists on the equipment or service (such as software with ISO 9241-171), then users of this International Standard can also refer to that more specific standard.

2.1.12. ISO TR 22411 - Ergonomic data and guidelines for the application of ISO/IEC Guide 71 to products and services to address the needs of older persons and persons with disabilities [20]

This technical report is a support document applying ISO/IEC Guide 71 in addressing the needs of older persons and persons with disabilities in standards development. It provides ergonomics data and knowledge about human abilities — sensory, physical and cognitive — and allergies, as well as guidance on the accessible design of products, services and environments.

2.1.13. ISO/IEC 24751 - individualized adaptability and accessibility in e-learning, education and training [21]

This standard, divided into three parts (framework and reference model, "Access for all" personal needs and preferences for digital delivery and "Access for all" digital resource description), is based on the work developed by the IMS Global Consortium on AccessForAll Meta-data [22] and contains metadata for describing accessibility features of learning objects and for describing accessibility-related personal needs and preferences.

2.1.14. ISO/IEC 24752 Information technology -- User interfaces -- Universal remote console [23]

This multi-part standard facilitates operation of information and electronic products through remote and alternative interfaces and intelligent agents. It defines a framework of components that combine to enable remote user interfaces and remote control of network-accessible electronic devices and services through a universal remote console (URC). The goal of the URC technology is that every device or service can be accessed and controlled by any control device and user interface that fits the user's needs and preferences, using suitable input and output modalities and interaction mechanisms. In the standard, the devices and services that are to be controlled are referred to as "targets", and to the control devices and their user interfaces as "universal remote consoles".

2.1.15. ISO/IEC 24756 Framework for specifying a Common Access Profile (CAP) of needs and capabilities of users, systems and their environments [24]

This standard defines a framework for specifying a common access profile (CAP) of needs and capabilities of users, computing systems, and their environments, including access supported by assistive technologies. It provides a basis for identifying and dealing with accessibility issues across multiple platforms in a standardized manner. It can be used to evaluate the accessibility of existing systems in particular environments for particular users.

2.1.16. ISO/IEC FDTR 29138 Information technology -- Accessibility considerations for people with disabilities [7]

This upcoming technical report is divided into three parts. Part 1, *User Needs Summary*, identifies a collection of user needs of people with disabilities for standards developers to take into consideration when developing or revising their standards. These user needs are also useful for developers of information technology products and services and for accessibility advocates to consider. Part 2, *Standards inventory*, identifies a collection of documents (which it refers to as standards even though they encompass more than traditional ISO and ISO/IEC standards) that provide guidance on meeting the needs of people with disabilities. Part 3, *Guidance on User Needs Mapping*, provides guidance on the mapping of the set of user needs with the provisions of a particular standard, technical report, or set of guidelines. It provides both basic guidance that should be used for all user needs mapping and optional guidance that may be added to the basic guidance.

2.1.17. W3C Composite Capability/Preferences Profile (CC/PP) [25][26]

A CC/PP profile is a description of device capabilities and user preferences. This is often referred to as a device's delivery context and can be used to guide the adaptation of content presented to that device. The Resource Description Framework (RDF) [27] is used to create profiles that describe user agent capabilities and preferences.

2.1.18. W3C – Web Accessibility Initiative recommendations [28]

These recommendations include accessibility guidelines for web content [29][30], user agents (browsers) [31] and authoring tools [32]. These are generally agreed to be the international reference concerning web accessibility.

2.2. Analysis of the standards

Once the standards were selected according to the above criteria, we decided to classify them to obtain a clearer picture of their scope. The criteria of classification in this case were two:

1. According to the *user orientation* [5], the standards may be:
   - User centred (U), they offer guidance on accessibility, design for all and general usability, from the viewpoint of the users of the product.
   - Developer centred (D), which are more technically oriented and provide technical solutions that developers can use to build products.
2. Depending on the *areas of modelling* that they address:
   - Content modelling (C)
   - User modelling (U)
   - Device modelling, including hardware and software (D)
   - Adaptation modelling (A)
   - User Interfaces modelling (UI)

The standards classification that addresses the accessibility, usability and adaptation in e-learning, according to the criteria of user orientation and areas of modelling, can be seen in Table 1. The results of this classification are covered by Table 2.

According to the results we can say that:

- There is a clear trend of the analyzed standards to guide their efforts towards the user and developer but rarely to both.
- There is a clear orientation towards addressing the user interface modelling and device modelling by the current usability and accessibility standards.

- The current user centred standards for usability and accessibility have a strong orientation towards addressing the user interfaces modelling and device modelling. It contrasts with their lack of support the user modelling and content modelling. The main reason for this is that they provide requirements from the viewpoint of the users and not technical solutions for the developers
- The current developer centred standards for usability and accessibility have a balanced orientation towards addressing the treated areas of modelling.

Table 1. Standards classification for A2UN@

Standard	User orientation		Addressing Areas of Modelling in A2UN@				
	U	D	C	U	D	A	UI
ETSI EG 202 116 V1.2.1	X				X		X
ETSI draft ES 202 746		X		X		X	
IEEE std. 1484.12.1-2002		X	X				
IMS AccLIP		X		X		X	
IMS AccMD		X	X			X	
IMS GDALA	X				X		
ISO 9241-110	X						X
ISO 9241-129	X			X		X	
ISO 9241-151	X		X				X
ISO 9241-171	X		X		X		X
ISO 9241-20	X				X		X
ISO TR 22411	X						X
ISO/IEC 24751		X	X	X		X	
ISO/IEC 24752		X			X		X
ISO/IEC 24756		X	X	X	X	X	X
ISO/IEC FDTR 29138	X					X	X
W3C CC/PP		X		X	X		
WAI-W3C	X	X	X		X		X

Table 2. Results of classification

Standards for areas of modelling	User centred standards for areas of modelling	Developer centred standards for areas of modelling
UI = 10	**UI = 8**	**U = 5**
D = 8	**D = 5**	**C = 5**
C = 7	C = 3	**A = 5**
A = 7	**A = 2**	**D = 4**
U = 6	**U = 1**	**UI = 3**

3. Conclusions and future work

There is a lack of standards that are oriented towards both users and developers and also addressing all areas of modelling treated. One of the expected results of the A2UN@ project is a standards-based conceptual model of LLL systems that meets that objective. Figure 1 shows an overview of the intended result.

The model should contain the basic elements of any LLL system , the relationships between those elements and, finally, the mappings between these elements and the corresponding requirements and recommendations from the existing standards. This is a difficult task, mainly due to two reasons.

Firstly, there are many conflicting standards that should be applied. For instance, in the Device Modelling area, there are at least 8 different standards applying to that issue, probably with different views.

Secondly, there are standards that apply to several areas. For instance, the user-oriented ISO 9241-20 standard applies to both device and user interface modelling.

In both cases there is a clear need for the model to provide a generic common vocabulary for describing LLL systems and their main components. And this common vocabulary should be designed to ease the development of mappings between the model and existing standards. We expect to have this model developed by the end of the second year of the A2UN@ project.

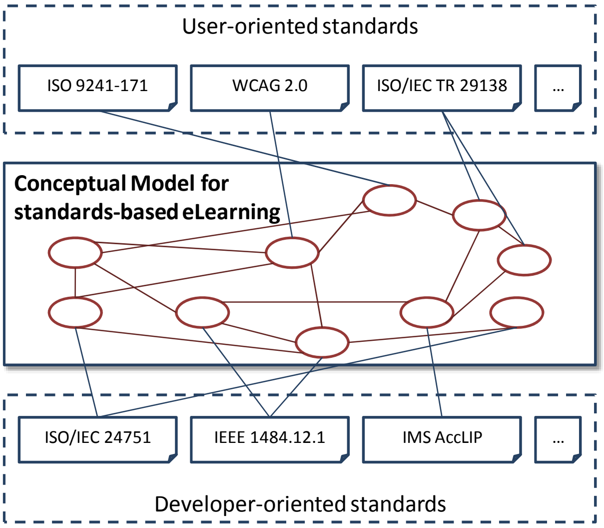

Figure 1. Model for LLL standards

Acknowledgements

German Moreno would like to thank the University of Girona for the financial support (UdG grant) awarded to assist in the completion of her Ph.D. dissertation. Furthermore, the authors of this paper declare that its realization is funded by A2UN@ project (TIN2008-06862-C04-01/TSI, TIN2008-06862-C04-02/TSI).

References

[1] EIID - European Institute for Design and Disability. Stockholm Declaration. Stockholm, 2004. (URL:http://www.designforalleurope.org/Design-for-All/EIDD-Documents/Stockholm-Declaration/)

[2] A Guide to Disability Rights Laws. U.S. Department of Justice, Civil Rights Division, Disability Rights Section. (2005) (URL: http://www.ada.gov/cguide.pdf).

[3] Santos, Olga C., et al. IMS-LD as a workflow to provide personalized support for disabled students in Higher Education institutions. TUMAS-A Workshop's Proceedings. 1, 2007, Vol. 1, 1.

[4] Department of Education and Science (2000). Learning for Life: White Paper on Adult Education. Dublin: Stationery Office. (URL:http://eric.ed.gov/ERICDocs/data/ericdocs2sql/content_storage_01/0000019b/80/1a/c6/5e.pdf)

[5] Martinez-Normand Loïc, Software Accessibility Standards, User Modelling and Adaptive Systems. TUMAS-A Workshop's Proceedings . 1, 2007, Vol. 1, 1.

[6] Hodgkinson, R. (2009) 9th Report on International ICT Accessibility Standards Proposed, Being Developed and Recently Published (April 2009). (URL:http://www.tiresias.org/research/standards/report_9.htm)

[7] ISO/IEC FDTR 29138 Information technology -- Accessibility considerations for people with disabilities. (2009)

[8] ETSI EG 202 116 V1.2.1: Human Factors (HF); Guidelines for ICT products and services; "Design for All". ETSI Guide. (2002)

[9] ETSI draft ES 202 746 - User profile preferences and information. V0.0.16 2009.

[10] IEEE Std. 1484.12.1-2002. IEEE Standard for Learning Object Metadata. IEEE Standard (2002)

[11] IMS Global Learning Consortium: IMS Learner Information Package Accessibility for LIP Information Model. Version 1.0 Final Specification (2003) (URL:http://www.imsglobal.org/accessibility/acclipv1p0/imsacclip_infov1p0.html)

[12] IMS Glogal Learning Consortium: IMS Learner Information Packaging Information Model Specification. Final Specification Version 1.0 (2003) (URL:http://www.imsglobal.org/profiles/lipinfo01.html)

[13] IMS Glogal Learning Consortium: IMS AccessForAll Meta-data Information Model Specification. Final Specification Version 1.0 (2004) (URL:http://www.imsglobal.org/accessibility/accmdv1p0/imsaccmd_infov1p0.html)

[14] IMS Global Learning Consortium: IMS Guidelines for Developing Accessible Learning Applications. Version 1 white paper (2002) (URL:http://www.imsglobal.org/accessibility/accessiblevers/index.html)

[15] ISO 9241-110. Ergonomics of human-system interaction - Part 110: Dialogue principles International Standard. ISO. (2006)

[16] Ergonomics of human-system interaction -- Part 129: Guidance on individualization. Draft International Standard. (2009)

[17] ISO 9241-151. Ergonomics of human-system interaction - Part 151: Guidance on World Wide Web user interfaces. Draft International Standard. ISO. (2008)

[18] ISO 9241-171. Ergonomics of human-system interaction - Part 171: Guidance on software accessibility. Draft International Standard. ISO. (2008)

[19] ISO 9241-20. Ergonomics of human-system interaction - Part 20: Accessibility guidelines for information/communication technology (ICT) equipment and services. Draft International Standard.ISO. (2008).

[20] ISO TR 22411. Ergonomics data and guidelines for the application of ISO/IEC Guide 71 to products and services to address the needs of older persons and persons with disabilities. (2008)

[21] ISO/IEC 24751. Information technology - Individualized adaptability and accessibility in e-learning, education and training (3 part document). (2008)

[22] IMS Global Learning Consortium: IMS AccessForAll Meta-data Overview. Version 1.0. (2004) (URL:http://www.imsglobal.org/accessibility/accmdv1p0/imsaccmd_oviewv1p0.html)

[23] ISO/IEC 24752. Information technology -- User interfaces -- Universal remote console. (5 part document). (2008)

[24] ISO/IEC 24756. Information technology -- Framework for specifying a common access profile (CAP) of needs and capabilities of users, systems, and their environments. (2009)

[25] Klyne, G., Reynolds, F., Woodrow, C., Ohto, H., Hjelm, J., Butler, M.H., Tran, L. (eds): Composite Capability/Preference Profiles (CC/PP): Structure and Vocabularies 1.0. W3C Recommendation 15 January. (2004) (URL: http://www.w3.org/TR/CCPP-struct-vocab/)

[26] Kiss, C. (ed): Composite Capability/Preference Profiles (CC/PP): Structure and Vocabularies 2.0. W3C Working Draft 8 December. (2006) (URL: http://www.w3.org/TR/2006/WD-CCPP-structvocab2-20061208)

[27] Manola, F., Miller, E. (eds): RDF Primer. W3C Recommendation 10 February. (2004) (URL:http://www.w3.org/TR/rdf-primer/)

[28] World Wide Web Consortium: Web Accessibility Initiative. (2008) (URL:http://www.w3.org/WAI/)

[29] Chisholm, W., Vanderheiden, G., Jacobs, I. (eds): Web Content Accessibility Guidelines 1.0. World Wide Web Consortium Recommendation (1999) (URL: http://www.w3.org/TR/WCAG10/)

[30] Caldwell, B., Cooper, M., Guarino, L., Vanderheiden, G. (eds): Web Content Accessibility Guidelines 2.0. W3C Recommendation 11 December 2008 (URL: http://www.w3.org/TR/WCAG20/)

[31] Jacobs, I., Gunderson, J., Hansen, E. (eds.): User Agent Accessibility Guidelines 1.0. World Wide Web Consortium Recommendation (2002) (URL: http://www.w3.org/TR/UAAG10/)

[32] Treviranus, J., McCathieNevile, C., Jacobs, I., Richards, J. (eds): Authoring Tool Accessibility Guidelines 1.0. World Wide Web Consortium Recommendation (2000) (URL:http://www.w3.org/TR/ATAG10/)

The Potential for Open Learner Models in Adaptive Virtual Learning Environments

Jeimy VÉLEZ[a,b,] Ramon FABREGAT[b], Susan BULL[c] and David HUEVA[b]
[a] *University Pontificia Bolivariana Montería, Colombia*
[b] *University of Girona, Spain*
[c] *Electronic, Electrical and Computer Engineering, University of Birmingham, UK*

Abstract. This paper presents the initial design of an Open Learner Model for an Adaptive Virtual Learning Environment (SAVEMA, The Spanish acronyms of Adaptive Educational Virtual System with Open Model), with the aim of helping learners to reflect on their knowledge, and to support their self-directed use of a Virtual Learning Environment.

Keywords. Adaptive virtual learning environments, open learner models

Introduction

In the context of virtual and blended education, several functionalities have been proposed for Learning Management Systems (LMS): intelligent LMS (iLMS) based on standards in aLFanet [1]; integration of the LMS Moodle (Modular Object-Oriented Dynamic Learning Environment) and the adaptive hypermedia system (AHS) APeLS (Adaptive Personalized eLearning Service) [2]; recommending service integrated into the OpenACS/dotLRN framework via Web services in ALPE, EU4ALL, ADAPTAPlan [3]; an adaptive virtual learning environment based on an Integral user model [4]. Each of these works add adaptive characteristics to an existing LMS through learner models. However, in these approaches the learner does not have access to their learner model.

Learning management systems or courseware management systems offer a wide variety of functionalities, such as integrating instructional material, e-mail, chat sessions, online discussions, forums, assignments, etc. Recently some environments have been extended to support standards and specifications in E-learning [5, 6]. Although these characteristics make this kind of system more versatile, and extensions give them the potential for adaptive characteristics, even the most advanced LMS systems tend to be used similarly to more traditional computer-assisted instruction support.

On the other hand, many educational research projects have built systems which may have lost some of the versatility, but gained characteristics such as: adaptive behavior [7; 8; 9]; support for collaborative learning [10; 11] and promoting reflection [12; 13; 14], encouraging learner independence and responsibility [15], improving accuracy of the learner model [13; 14]; helping learners to plan and/or monitor their learning [13; 14] and affording learners greater control over their learning [16] through an Open Learner Model (OLM), among others. Although their use is generally more restricted than LMS (for example, to a specific domain, or in specific research studies), these approaches have shown some positive results, specifically system which have open the learner model to the students in the educational area.

In [17] Adaptive Virtual Learning Environment named SAVE (the Spanish acronyms of Adaptive Educational Virtual System) has been proposed. SAVE use the LMS dotLRN which, besides be open source, has been suggested as useful for reusability, accessibility [18] and usability [19]. The dotLRN platform was extended with adaptive characteristics based on the competence levels of each learner. To carry out the adaptive behavior, a unit of learning (UoL) has been designed with the IMS learning design specification [IMS-LD]. During the design phase, the instructor defines some variables which are used to set the competence level of the student. The competence level is inferred by a multi-agent system (MAS) based on the questions answered by the learner in tests with IMS questions and test interoperability [IMS-QTI]. The adaptive behavior is then obtained through the different paths previously defined in the UoL. (Further details can be found in [4]).

To improve SAVE an Open Learner Model is proposed, this new proposed system is named SAVEMA (the Spanish acronyms of Adaptive Educational Virtual with Open Model). This paper focuses on the potential for opening the learner model in AVLEs and the design of an OLM in SAVE.

The paper is organized as follow: In section 1 the Open Learner Model (OLM) and relations with Adaptive Virtual Environment (AVLE) are introduced. In section 2 details about the learner model and adaptive characteristics of the Unit of Learning (UoL)/course are presented. In section 3 initial design of SAVEMA is proposed. Finally, the summary is presented.

1. The Potential for Using an OLM in an Adaptive VLE

Open Learner Models (OLM) are learner models that can be accessed by the user, in full or in part, and have been used for a variety of purposes, e.g. improving accuracy of the learner model; promoting learner reflection; helping learners to plan and/or monitor their learning; and affording learners greater control over their learning [20].

At this stage of our work we focus on promoting learner reflection on their competence level, as an important element to facilitate meta-cognitive behavior, in accordance with suggestions that students who engage at a meta-cognitive level tend to achieve significantly higher learning results [21]. In [22] reflection is defined as “a generic term for those intellectual and affective activities in which individuals engage to explore their experiences in order to lead to a new understanding and appreciation”. There is evidence to suggest that effectiveness in the learning process could be enhanced when a student reflects about their own knowledge [22; 23; 24]. Along the same lines, it has been argued that OLMs have the potential to foster reflection and meta-cognitive skills, as the system provides the user with a representation of their understanding of a subject as a starting point [15]. Learning gains have indeed been demonstrated in some instances, using a simple OLM presentation [25; 26].

As adaptive capabilities are added to a traditional VLE, learner model is available to open to the user. The considerations and characteristics of this OLM are presented below.

2. Learner Model and Adaptive Courses in SAVEMA

In this section general details about the learner model and adaptive characteristics of the course are presented. The open learner model design in SAVEMA is presented in the next section.

2.1. Learner Model

The learner model of the VLE is presented in accordance with the three layers identified for the analysis of user models by Brusilovsky and Millan in [27]: what is being modeled (nature), how this information is represented (structure) and how different kinds of models are maintained (user modeling approaches).

The information represented in our learner model relates to competences; although there are similarities with knowledge representation, the differences can be found in the conception and the implications that these have for the learning process. The competences are structured in a taxonomy (e.g. for a career, high school program), defined with the IMS Reusable Definition of Competency or Educational Objective [28] specification, and implemented as shown in figure 1.

As an overlay approach has been used [28], the implementation takes into account the UoL structure used to build the domain model. The learner model is maintained through a multi-agent system which builds and updates the learner model overlaying the domain model with the competence level obtained by the student after answering questions in the respective UoL [4].

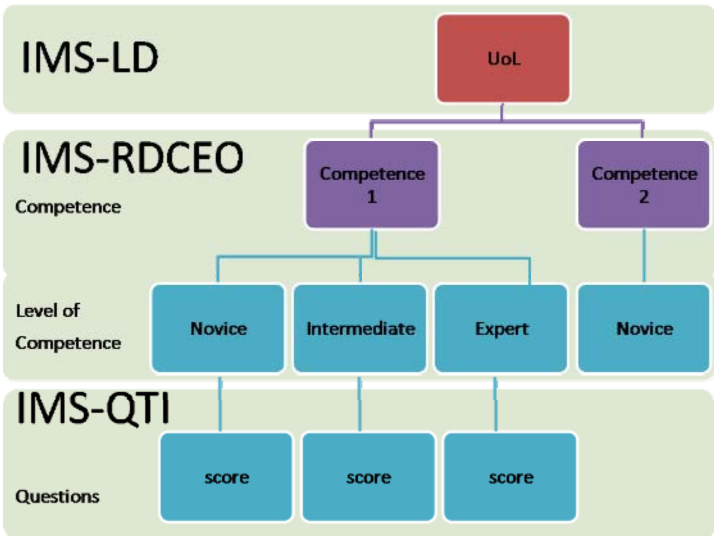

Figure 1. Structure of the learner and domain model.

In figure 1, each division shows the specification used and the relations defined between them. The structure of the domain model is based on components identified in a competence proposed by Tobón in [29]. Tobón proposes a model which considers tree elements in a competence: problems that the competence address to solve, description of the competence which summarizes the main idea of the competence and their context and criteria for evaluate if a competence is achieved or not. Besides, Bloom taxonomy [30] has been used to classify development criteria in a competence [31] (see table 1), and also for question classification. In table 1, competence levels are defined: novice, intermediate and expert.

Table 1. Level of competence based on Bloom's taxonomy

BLOOM OBJECTIVE	DESCRIPTION (COGNITIVE DOMAIN)	LEVEL
Knowledge	Remembers a fact without a real understanding of the meaning	Novice
Understanding	Gets the meaning of the material	
Application	Can use the learned material in new and specific situations	Intermediate
Analysis	Can divide a complex problem into different parts	
Synthesis	Can join different parts in order to create new entities	
Evaluation	Can judge values of a subject with a specific propose	Expert

2.2. Adaptive Course

The adaptive course was designed for students in the Universidad Pontificia Bolivariana in Colombia as a part of an introductory computing course for informatics students. The course includes the topic Object Oriented Programming (OOP), which has been used as the main topic for the design of the virtual course. Many of the resources used for course generation were taken from SHABOO [32], and other resources were provided by the course instructor. The course includes three parts: Introduction, Objects and Class, and was built using the authoring tool "Reload Learning Design Editor" and IMS-LD [33] specification.

The designer defines the level and number of competence(s) that could be achieved in a course by a learner. In the Unit of Learning/course used two competences were defined. The first competence could be achieved until novice level and the second one could be achieved until intermediate level. Rules for adaptive behavior in accordance with the competence level of each student were defined in the IMS-LD. These rules take into account the values of each variable for carrying out the adaptation. However, these variables need to be updated during run time. On completion of the design phase, the UoL was uploaded to the dotLRN VLE and a run was created with the package ims-ld for the Unit of Learning/course available for the students. Because the variables in the package ims-ld in dotLRN need to be updated manually, we have integrated it with a multi-agent system which performs this task (additional detail can be found in [4]).

The Unid of Learning was loaded in the dotLRN platform that runs on a server in UPB [34]. On this platform a class named Object Oriented Programming was created; in which students have different services such as forums, chat, space to store and share files, calendar, news, questionnaires, units of learning, among others. In the link to units of learning, students can choose the UoL available to them.

The course was available for one month, and two tests were administered, in the middle and at the end of the course for evaluate the student competence in the course.

The questions were designed mostly in SHABOO [32] and characterized with the IMS-QTI [35] specification in the package Assessment in dotLRN. Each question is identified with an id that allows the competence, the level and the performance criterion that it assesses, to be tracked. A low average was obtained by the students in the two tests. (The averages for the two tests are based on a scale from 0 to 5, and were 3.49 and 2.77 respectively.) We therefore aim to increase user engagement as has previously been found to occur with the introduction of a simple OLM [36], in an AVLE context.

3. SAVEMA in the SMILI☺ OLM Framework

The SMILI☺ OLM framework [20] is designed to help researchers to focus on the main considerations for opening a learner model. These considerations have been used in this section to present the description of our OLM. The framework include an overall view in the OLM design which help to the designer focus on the main considerations for open a learner model. The framework take into account the purpose, what is modeled, how is the model presented and who controls de access to the model. Furthermore some additional aspects are considered in each one of these considerations, (see tables 2 to 5).

Table 2. Purpose of Open Learner Modelling.

Purpose	*Accuracy*	*Reflection*	*Plan / Monitor*	*Collab / Competition*	*Navigation*	*Right of access, control, trust*	*Assessment*
SAVEMA		XX					

In the table No. 2 the upper part shows the general issues. The lower part shows the goals of openness of the learner model: XX for central goals; X for lesser goals and x for minor concerns. There are many purpose for open a learner model, however in this work the reflection purpose have been chosen as a way of promote meta-cognitive state that encourage the autonomy and responsibility in the learning process.

Table 3. WHAT is modeled?

Elements / Purpose	Properties	*Reflection*
1. Extent of model accesible	Complete	

	Partial	X
2. Match underlying representation	Competence level Knowledge Difficulties Misconceptions	X
3. Access to uncertainty	Learning issues Preferences Other Other users' LM	
4. Role of time	Previous Current Future	X X
5. Access to sources of input	Complete Partial	 X
	System Self Peer Instructor Other	X
6. Access to model effect on personalization	Complete Partial	

In the table 3 what is modeled is summary. The main aspects considered are that the open learner model shows the competence level which take into account the current and previously level achieved. Only the system has access to the sources input and the learner model is showed in a partial way because there is some additional information in the learner model that at this time is not opened.

Table 4. HOW is the model presented?

Elements / Purpose	Properties	*Reflection*
7. Presentation	Textual (i.e...) Graphical (i.e...)	 X (level, skill meter and colours)
	Overview Targeted/all Details All Details	 X
8. Access method	Inspectable Editable Addition Student persuade System encourage Negotiated	X
9. Flexibility of access	Complete Partial	

In the table 4 the way as the model is presented is described. The learner model is presented in a skill meter way with some colors that help to identify levels and competences. Not all details are available at this design in the leaner model. There are different methods for do that presentation of the model. The inspectable method has been chosen in the presentation of the learner model in SAVEMA, this means that the student can view their learner model.

Table 5. WHO controls access to the model?

Elements / Purpose	Properties	*Reflection*
10. Access initiative comes from	System User Peer Instructor Other	 X
11. Control over accessibility (to others)	Complete Partial	
	System Peer Instructor Other	X

Finally in the table 5 details about who control the access to the models is given. In the design of this OLM the user access are defined but the student cannot decide what is available to see.

In figure 2 the OLM is presented. On the left side, the competence levels novice, intermediate and expert are shown using the colors yellow, blue and green, respectively. Others visual effects are added to facilitate their differentiations. On the right hand side, a skill meter is used for each competence at a specific level. Skill meters were chosen as they are one of the most common forms of simple OLM adopted in systems [e.g. 25; 37; 38], and have enjoyed high levels of use in real (voluntary) use settings to support university courses [36; 39].

As we have said, in the Unid of Learning/course design a competence could have until tree levels: Novice, Intemediate and Expert. The number of levels depends of the scope that the designer consider achievable. Because the designer of the course used has considered only two levels, figure 2 does not show any criterion in the expert level. The first competence has two criteria and the second one has one criterion. The skill meter shows how much the learner has achieved in a specific level for a specific competence.

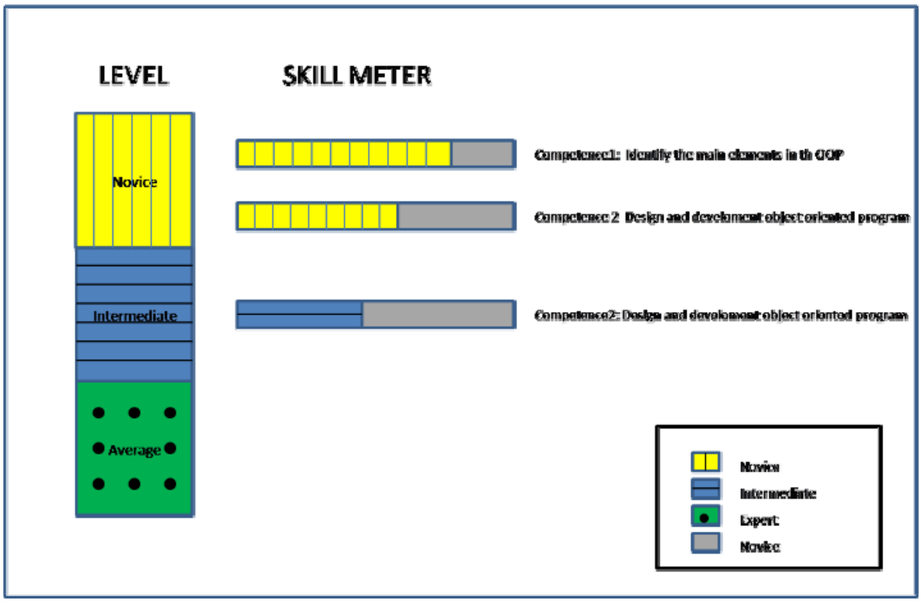

Figure 2. Open Learner Model representation in SAVEMA.

4. Summary

SAVEMA was created with the purpose of achieving reflection in the context of an adaptive VLE. The OLM represents competence level: novice, intermediate and expert, which have been defined based on Bloom's taxonomy [30]. The presentation of the learner model is done through the use of levels, skill meters and colors, and the method of access to the learner model is 'inspectable' – i.e. the learner can view their learner model, but may not directly contribute information about their knowledge. Although some preliminary studies have been done for validate SAVEMA this paper focus on the design of OLM. Future work will deploy new designs of OLM and also other studies to investigate the extent to which a OLM may facilitate use of a VLE; and investigate whether students might also benefit from an OLM using other features described in the SMILI☺ Framework, in the AVLE context.

References

[1] Santos, O.C., Boticario, J.G. and Barrera, C. (2004). A Machine Learning Multi-Agent Architecture to provide adaptation in a standards-based Learning Management System. WSEAS Transactions on Information Science and Applications Vol. 1 468 – 473

[2] Tiarnaigh, M. (2005) An integration of Moodle (Modular Object-Oriented Dynamic Learning Environment) with an AHS (Adaptive Hypermedia System). Final Year Project.

[3] Santos, O.C., Raffenne, E., Granado, J., and Boticario, J.G. (2008). Dynamic support in OpenACS/dotLRN: Technological infrastructure for providing dynamic recommendations for all in open and standard-bsed LMS. OpenACS and .LRN conference. International Conference and Workshops on Community based environments, Guatemala.

[4] Vélez, J., Fabregat, R., Nassiff, S., Fernandez, A., and Petro, J. (2008) User Integral Model in Adaptive Virtual Learning Environment. World Conference on E-Learning in Corporate, Government, Healthcare, & Higher Education, E-Learn.
[5] dotLRN. http://dotlrn.org/
[6] Moodle. http://moodle.org/
[7] Henze, N. (2000). PhD Thesis, Adaptive Hyperbooks: Adaptation for Project-Based Learning Resources.
[8] De Bra, P., and Stash, N. (2002). AHA! Adaptive Hypermedia for All. SANE Conference, Maastricht.
[9] Cristea, A. Floes, D. Stash, N. and De Bra, P. (2003). MOT meets AHA!, PEG'03, St. Petersburg, Russia.
[10] Olguin, C.J., Delgado, A.L., and Ricarte, I.L. (2000). An Agent Infrastructure to Set Collaborative Environments. Educational Technology & Society, 3(3), 65-73
[11] Alfonseca, E., Carro, R., Martín, E., Ortigosa, A., Paredes, P. (2006). The impact of learning styles on student for collaborative learning: a case study. Computer Science and Humanities, Social Sciences and Law Issue Volume 16, Numbers 3-4
[12] Kay, J., Li, L., and Fekete, A. (2007). Learner reflection in student self-assessment. In Proceedings of ACE 2007, 9th Australasian Computing Education Conference, pages 89-95. Australian Computer Society.
[13] Bull, S., and Pain, H. (1995). Did I say what I think I said, and do you agree with me? Inspecting and Questioning the Student Model. In J. Greer (Ed.) Proceedings of the World Conference on Artificial Intelligence in Education (pp. 501-508). Charlottesville, VA, USA: Association for the Advancement of Computing in Education.
[14] Bull, S., and McKay, M. (2004). An Open Learner Model for Children and Teachers: Inspecting Knowledge Level of Individuals and Peers. In J.C. Lester, R.M. Vicari & F. Paraguaçu (Eds.) Intelligent Tutoring Systems: 7th International Conference, ITS 2004 (pp. 646-655). Berlin Heidelberg: Springer-Verlag.
[15] Bull, S. and Kay, J. (2008). Metacognition and Open Learner Models, in I. Roll & V. Aleven (eds), Proceedings of Workshop on Metacognition and Self-Regulated Learning in Educational Technologies, International Conference on Intelligent Tutoring Systems, 7-20.
[16] Czarkowski, M., and Kay, J. (2000). Bringing scrutability to adaptive hypertext teaching. In G. authier, C. Frasson & K. VanLehn (Eds.) ITS '00: Proceedings of the 5th International Conference on Intelligent Tutoring Systems (pp. 423-433). London: Springer-Verlag.
[17] Vélez, J. and Fabregat, R.: SAVE: Sistema Adaptativo Virtual de Educación. Submitted to Conferencia de la Asociación Española para la Inteligencia Artificial (CAEPIA), Sevilla, España. 9-13. November 2009
[18] Santos, O.C. Boticario, J.G. Raffenne, E. and Pastor, R. (2007). Why using dotLRN? UNED use cases. 1st International Conference on FLOSS: Free/Libre/Open Source Systems.
[19] Martin, L., Roldán Martinez, D., Revilla, O., Aguilar, M.J., Santos, O.C., and Boticario, J. (2008). Usability in e-Learning Platforms: heuristics comparison between Moodle, Sakai and dotLRN. OpenACS and .LRN conference 2008. International Conference and Workshops on Community based environments, Guatemala.
[20] Bull, S. and Kay, J. (2007). Student Models that Invite the Learner In: The SMILI☺ Open Learner Modelling Framework, International Journal of Artificial Intelligence in Education 17(2), 89-120.
[21] White, B.Y., and Shimoda, T. A, and Frederiksen, J.R. (1999). Enabling Students to Construct Theories of Collaborative Inquiry and Reflective Learning: Computer Support for Metacognitive Development. Int. Journal on AI in Education, 10 151-182.
[22] Boud, D., et al. (1985). Promoting reflection in learning: A model. Reflection: Turning Experience into Learning. D. Boud, R. Keogh and D. Walker. London, Kogan Page: 18-40.
[23] Schön, D. A. (1983). The reflective practitioner. New York, Basic Books.
[24] Schön, D. A. (1987). Educating the reflective practitioner. San Francisco, Jossey-Bass Publishers.
[25] Mitrovic, A. and Martin, B. (2007). Evaluating the Effect of Open Student Models on Self- Assessment, International Journal of Artificial Intelligence in Education 17(2), 121–144.
[26] Shahrour, G. & Bull, S. (in press). Interaction Preferences and Learning in an Inspectable Learner Model for Language, Artificial Intelligence in Education 2009, IOS Press, Amsterdam.
[27] Brusilovsky, P., and Millan, E. (2007). User Models for Adaptive Hypermedia and Adaptive Educational Systems. The Adaptive Web Book. Springer Berlin / Heidelberg. Vol. 4321, 3-53
[28] IMS Reusable Definition of Competency. Version1.0. Final Specification. 2002.
[29] Tobon, S. (2008). La Formación Basada en Competencias en la Educación Superior. Bogota: cife
[30] Bloom, B.S. (1956). Taxonomy of Educational Objectives. New York: David Mckay.
[31] Baldiris, S., Santos, O. C., Barrera, C., Boticario J. G., Velez, J., and Fabregat, R. (2008). Integration of educational specifications and standards to support adaptive learning scenarios in ADAPTAPlan.

International Journal of Computer Science and Applications (IJCSA). Special Issue on New Trends on AI techniques for Educational Technologies. Vol 5, 1
[32] Llamosa, R. Guarín, I. Moreno, G. and Baldiris, S. (2003). Sistema Hipermedia Adaptativo para la Enseñanza de los Conceptos Básicos de la Programación Orientada a Objetos. Universidad Industrial de Santander, Coordinador CIDLIS.
[33] IMS Learning Design. Version 1.0 Final Specification, 2003.
[34] UPB Server with dotLRN installed. http://64.76.48.166:8999/
[35] IMS Question and Test Interoperability. Version 1.2.1 Final Specification, 2003.
[36] Bull, S., Mabbott, A., Gardner, P., Jackson, T., Lancaster, M., Quigley, S. and Childs, P.A. (2008). Supporting Interaction Preferences and Recognition of Misconceptions with Independent Open Learner Models, Adaptive Hypermedia 2008, Springer-Verlag, Berlin Heidelberg.
[37] Papanikolaou, K.A., Grigoriadou, M., Kornilakis, H., and Magoulas, G.D. (2003). Personalizing the Interaction in a Web-Based Educational Hypermedia System: The Case of INSPIRE. User-Modeling and User-Adapted Interaction, 13(3), 213-267.
[38] Weber, G., and Brusilovsky, P. (2001). ELM-ART: An adaptive versatile system for Web-based instruction. International Journal of Artificial Intelligence in Education. 12(4), 351-384.
[39] Bull, S., Quigley, S. & Mabbott, A. (2006). Computer-Based Formative Assessment to Promote Reflection and Learner Autonomy, Engineering Education: Journal of the Higher Education Academy Engineering Subject Centre 1(1), 8-18.

Management of recommendations for accessible eLearning platforms: is it a need for learning management system users?

Olga C. SANTOS, Ludivine MARTIN, Emanuela MAZZONE
and Jesus G. BOTICARIO
aDeNu Research Group. Artificial Intelligence Department. UNED
Calle Juan del Rosal, 16. Madrid 28040. Spain
{ocsantos, ludivine.martin, emazzone, jgb}@dia.uned.es

Abstract. The objective of this paper is to open a discussion within the workshop regarding the particularities of recommendations in the eLearning domain. In particular, in the context of learning management systems (LMS) that support inclusive scenarios, we aim to discuss the utility of an authoring tool for teachers to manage the recommendations provided by the LMS to students. The objective of this tool is twofold: 1) to facilitate the involvement of teachers in the process of understanding the needs of users when providing recommendations in the eLearning domain, and 2) to offer teachers a control mechanism on what is recommended to users.

Keywords. Recommender systems, Accessibility, Authoring tools, eLearning.

Introduction to the discussion topic

In a world where information overload is constant, recommender systems (RS) represent a highly valuable feature: they aim to offer the most relevant products, services or guidance to each specific user. RS are based on technologies processing previous interactions with the system from a specific user or from similar users. Typical examples of RS are found in commercial web services (e.g.: Amazon, YouTube, LastFM. In the eLearning domain, at this time none of the major eLearning platforms, being commercial or open-source, include a RS. And it is a fact that in learning management systems (LMS) information overload exist.

In aDeNu R&D group, we are developing a RS within the context of an e-learning platform that takes into account not only the user preferences, but also psycho-educational considerations. Following a user centered design process, we have found out that in the case of e-learning scenarios involving interactions with a teacher, there is a need for a validation step, before publishing a recommendation. This “manual” step deviates from the initial concept of RS where recommendations are generated and published automatically using artificial intelligence techniques such as collaborative filtering and content-based filtering. Our approach is not to substitute the algorithms by the teachers’ knowledge (as in expert systems) but to provide a tool to facilitate the involvement of teachers in the process. It follows two objectives: 1) to offer a tool where teachers can modify, design and experiment recommendations, and 2) to offer teachers a control mechanism on what is recommended to users. Teachers can benefit from the reduced workload coming from the analysis of the users' interactions and the generation of recommendations regarding platform support with artificial intelligence techniques. But they also want to have visibility and control on what is recommended to their learners within the course.

The research questions that we aim to solve are:

- What are the needs of users of LMS?
- What psycho-educational support is required in inclusive eLearning scenarios?
- What types of situations are meaningful for providing recommendations?
- Which is the best action each learner should perform in each situation?
- What type of recommendations can best benefit to the learners?
- What is the most appropriate design for the teacher's tool to manage recommendation?

Currently, we are focusing on the needs of learners to improve the efficiency, effectiveness and satisfaction during their learning, and how the teacher can be supported in her tutoring task with a RS. A useful recommendation for a learner depends on many variables/factors: the user's learning goals, the progress in the course, the quality of the contents contributed by other members, etc. Given the complexity of the learning context, it is not possible to design in advance the most appropriate navigation path for each learner in each situation as instructional design theories propose, but it has to be dynamically built taking into account the current learner features, her context and past interactions (of other users, whether they have been can be successful or not). Recommendations offer a personalized way to guide learners through the wide spectrum of possible actions to in the course. An adaptive system is required for such a personalized navigation support. In this respect, RS is considered a suitable solution to provide adaptive responses to users' interactions.

Our innovation here is to offer the teacher a tool to validate and modify the recommendations generated by the algorithms, as well as to introduce new ones that consider psycho-educational needs that may not have been covered by the algorithms. Two hypothesis support this idea (which are to be validated) are: i) teachers feel more confident with this control over the recommendations and ii) for the algorithms, this human input is useful to improve the quality and utility of the recommendations generated. The main research goal now is to understand the needs of learners in LMS. For this, a scenario-based user centred design process has been defined that involves teachers in the process to elicit relevant eLearning situations and what recommendations could be provided in them. We are designing an authoring tool that can be used by the teacher to create new recommendations and manage those that are given to the learners. The design of the authoring tool needs to take into account the conceptual model of the users in order to provide a simple interface for managing a complex system as it is the RS.

We would like to take advantage of the expertise of the audience of the workshop to discuss the particularities of recommendations in the eLearning domain. In particular, in the context of LMS that support inclusive scenarios, whether an authoring tool for teachers to manage the recommendations is perceived as useful.

Acknowledgements. The work presented here is framed in the context of the EU4ALL (IST-2006-034478) project funded by the European Commission & A2UN@ (TIN2008-06862-C04-01/TSI) project by the Spanish Government.

Expert System for Educational Content Selection Based on Standards

Santiago Pérez de la Cámara, Edgar Rubión Soler, Alicia Fernández del Viso Torre, Eva Vázquez de Prada, Carlos Rebate Sánchez
{sperezd, erubion, afernandezde, evazquezdeprada, crebate}@indra.es
eInclusion Unit, Indra Software Labs
C/ Acanto 11, 28045 Madrid (Spain)

Abstract. The most common approach to content selection for educational purposes is often focused on how to display these contents in the variety of devices that the user could have (PC, PDA, mobiles, etc.); neither user needs nor preferences are taken into account, nor the desired features for accessible content. This paper depicts the standard based Expert System that is being developed on the framework of the European project EU4ALL [European Unified Approach for Assisted Life Long Learning - IST-FP6-034778]. The goal of this component is to select the content that provides best adaptation to the user. The first prototype of this component has been developed following a SOA (Service Oriented Architecture) approach so it can be easily integrated with existing Virtual Learning Environment.

Keywords. Content selection, standards, accessibility, Expert Systems, SOA

Introduction

Nowadays many educational institutions open their virtual classes to students with different disability levels. The main challenge that students with disabilities face is to access education resources that are appropriate for them. Educational resources are usually the same for every student since no specific adaptation is provided to adapt the resource to the needs of the students. As a result, students cannot take full advantage of the learning experience that virtual learning environments offer. They are several works about the study of the content personalization as we can see in [1], [2], [3], [4] and [5].

In this paper we depict the solution proposed to solve this situation, the first prototype of the Content Personalization service (CP), a module that selects the most suitable resource for a specific student taking into account preferences, device properties and resource properties together with the adaptations available.

1. Content Personalization

The main goal of EU4ALL project is to design and implement an extensible architecture of services to support accessible lifelong learning for adult learners with special needs. These services are to be open, secure, standard-based, accessible and interoperable.

The CP is a component in the EU4ALL project. It is a resource selection module. The goal of the CP is find the most suitable resource resolving a request coming from a Virtual Learning Environment (VLE) and returning an identifier for the chosen resource. This way, the module provides users with the educational resource that best adapts to the preferences and needs of the student. To choose the best resource, the CP processes the user preferences (stored in the user profile), the device preferences (stored in the device profile) and the characteristics of the requested resource and its available adaptations (resource profile/adaptation).

The standards used to implement the profiles are:

- W3C CC/PP [7] (Composite Capability/Preference Profiles): Specification that defines the capabilities of the devices that the user is using. CC/PP is based on RDF (Resource Description Framework). In the EU4ALL project, we are using UAProf [8] (User Agent Profile) specification, based on the CC/PP standard. UAProf is concerned with capturing capability and preference information for devices, and this information can be used by content providers to produce content in an appropriate format for the specific device.
- IMS AccLIP [9] (Accessibility for Learner Information Package): AccLIP documents only store accessibility preferences of the user. It could be integrated with the standard IMS LIP [10] (Learning Information Package).
- ISO DRD [11] (Digital Resource Description, ISO/IEC 24751-3:2008): New standard use to describe the learning objects, both original resources and adaptations. ISO DRD is the 3rd part of the *Individualized adaptability and accessibility in e-learning, education and training specification ("Access for all")*. It provides a common language for describing digital learning resources to facilitate matching of those resources to learners' accessibility needs and preferences.

2. Content Personalization behavior

The behavior of the CP module is summarized in the figure 1.

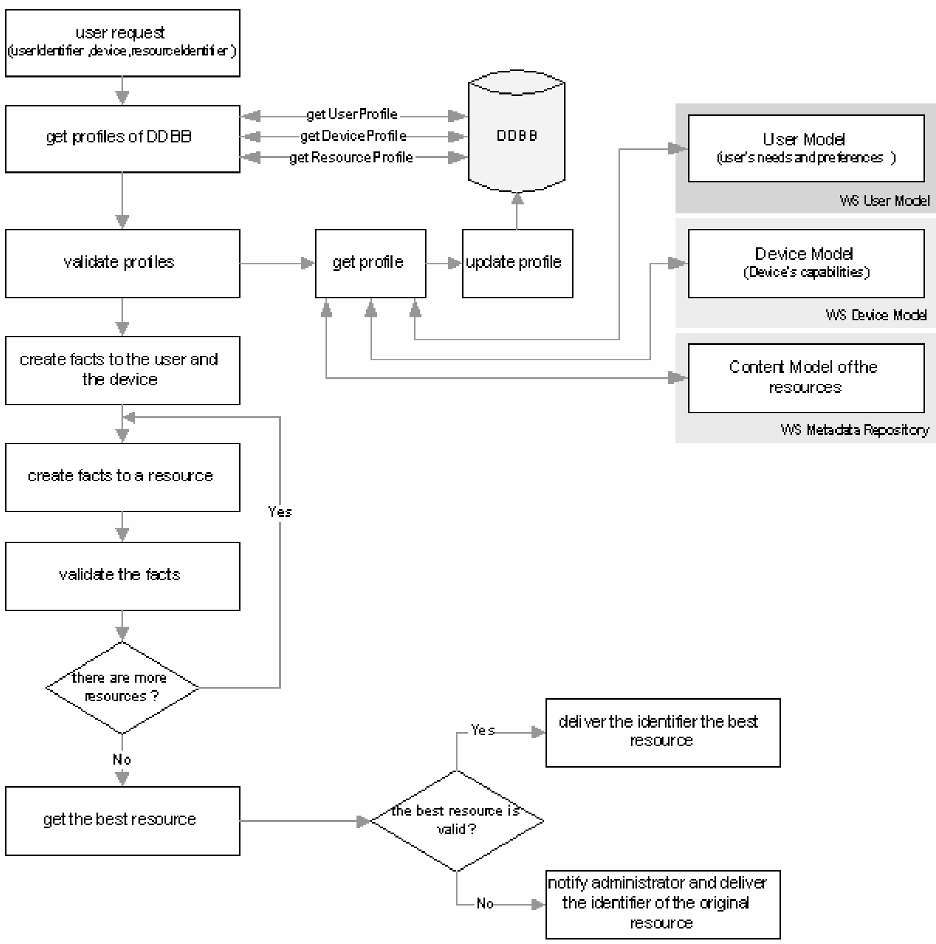

Figure 1. Flow diagram of the CP module

When the CP modules receives a request with the user identifier, a short description of the device and the resource identifier, the CP retrieves the profiles for the user, the device the resource and its available adaptations. There are two alternatives to retrieve the profiles, the first one to look for the profiles in the cache memory of the CP module and the second is to access the external modeling services (User modeling, Device modeling) via web services. In the first place, the CP module tries to retrieve the profiles from the cache, if these profiles are invalid or there are no profiles available, it tries to retrieve the profiles using external modeling services and it updates the cache with them. An invalid profile is a profile that has exceeded the timeout specified. The threshold for the timeout is configurable.

When all the profiles retrieved by the CP are valid, it creates the facts for the user and device profiles. The facts are implemented in an intermediate language understood by the rule based engine. The profiles of the original resource and its adaptations are translated into a group of facts, where each group has the facts that correspond to a resource or to an adaptation. Then the CP loads the facts for the user, the device and the resource/adaptation in the rule based engine, and it validates them getting a score for each resources. This score is stored together with the identifier of the analyzed resource. This operation is repeated until all the adaptations have been analyzed. Once the adaptations have been analyzed, if the resource/adaptation with the highest store is above a certain threshold, this will be marked as the most suitable resource for the user, as result, the CP returns the identifier of this resource. On the contrary, if the value for the highest score does not pass the threshold, the CP returns an identifier for the original resource and sends an e-mail to the administrator to notify that there is no adaptation available for a certain user and device.

3. Architectural Components of the Content Personalization Module

The CP module is made up of different components with the structure indicated in the figure 2.

3.1. Web Services Layer

The layer contains the available web services of the CP, and also it is used to access the external modeling services to obtain the profiles of the user, the device, the resources and the adaptations. By using web services it is possible to distribute the tasks among different modules that are completely independent without having to share features such as the programming language or the operative system. The first prototype for the CP uses Axis2 1.3 [12] for SOAP.

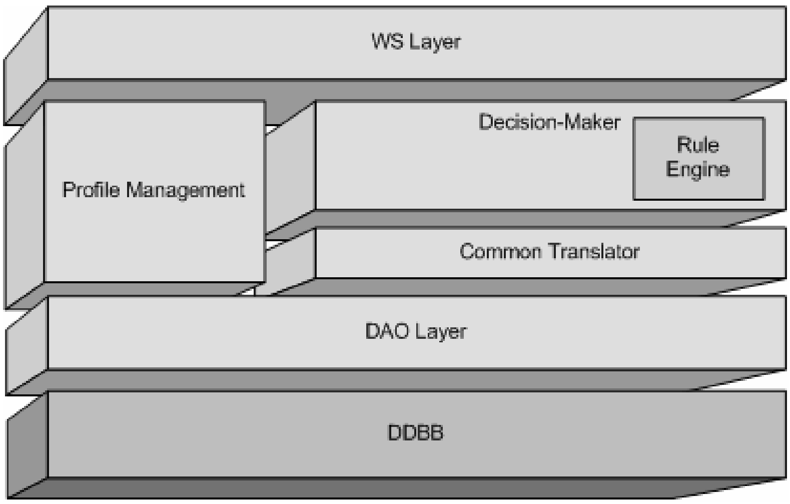

Figure 2. Content Personalization components

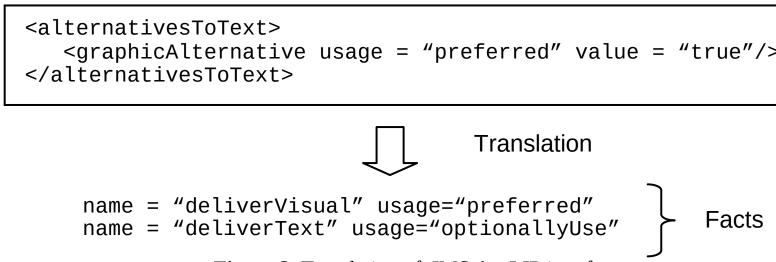

Figure 3. Translation of IMS AccLIP into facts

3.2. Common Translator

This component is in charge of translating the profiles to facts. These facts are implemented in an intermediate language managed by Decision-Maker. It will interpret the facts in order to validate the different resources and the adaptations. This way, the CP is standard independent by using Decision-Maker, since it works with an intermediate language. This eases the integration of new standards with the CP. To manage a new standard only implies to modify the Common Translator module, providing it with the capability to translate the new Standard into the intermediate language. The Common Translator component uses Jena 2.5.6 [14] libraries, which is a framework for semantic web that is also used to manage CC/PP standard through RDF. Figure 3 shows a translation example of a fragment of IMS AccLIP into facts. Of one user prefers a graphical alternative over a textual resource, this is translated to two facts; the first one is to deliver the visual resource as the preferred one and the second is to deliver the textual resource as the optional one. The values of the usage fields in the facts show that the user prefers a visual resource, but if it does not exist he accepts a textual resource. These facts mean the same that the piece of IMSAccLIP where the user prefers the visual resource, but he does not require it. Note that the *"usage"* attribute is setting the level of preference in the IMS AccLIP and could be *"preferred"*, *"optionallyUse"*, *"required"* or *"notUse"*.

3.3. Decision-Maker

This component is in charge of validates the facts. The first prototype for the CP module uses Drools [15] as rule based engine. The module provides a simple way to take AI decisions. The following code features an example for a rule that decides is a resource is valid. In the first prototype of the CP, a resource is valid if the visual, textual, auditory, format and language bits are valid. The rule `"Visual missing"` checks id the resource is not visual and the user required a visual resource. The rule `"Hardware visual ok"` checks if the device is compliant with the hardware handed to display a visual resource. `"User visual ok"` checks if the user wants a visual resource, and `"Visual ok"` checks if the hardware can handle a visual resource and if it is accepted by the user. Finally, the rule `"Visual ko"` is the oposite operation to `"Visual ok"` and decides when the user does not want a particular resource or when the hardware is not appropriate.

```
rule "Visual missing"
  no-loop true
  when
    not(exists(ResourceCharacteristic(name==“accessMode”, value==“visual”)))
    UserPreference(name==“deliverVisual”, usage!=“required”)
    $mUserVisualOk:Message(message==“userVisualOK”)
    $mHardwareVisualOk:Message(message==“hardwareVisualOk”)
  then
    $mUserVisualOk.setValue(true);
    update($mUserVisualOk);
    $mHardwareVisualOk.setValue(true);
    update($mHardwareVisualOk);
end

rule "User visual ok"
  no-loop true
  when
    ResourceCharacteristic(name==“accessMode”, value==“visual”)
    UserPreference(name==“deliverVisual”, $usage:usage!=“notUse”)
    $mUserVisualOk:Message(message==“userVisualOk”)
  then
    $mUserVisualOk.setValue(true);
    $mUserVisualOk.setUsage($usage);
    update($mUserVisualOk);
end

rule "Hardware visual ok"
  no-loop true
  when
    ResourceCharacteristic(name==“accessMode”, value==“visual”)
    DeviceCharacteristic(name==“imageCapable”,
                         value=="Yes"||value==null)
    $mHardwareVisualOk:Message(message==“hardwareVisualOk”)
  then
    $mHardwareVisualOk.setValue(true);
    update($mHardwareVisualOk);
end

rule "Visual ok"
  no-loop true
  when
    Message(message==“userVisualOk”, value==true, $usage:usage)
    Message(message==“hardwareVisualOk”, value==true )
    $mVisualOk:Message(message==“visualOk” )
  then
    $mVisualOk.setValue(true);
    $mVisualOk.setUsage($usage);
    update($mVisualOk);
end

rule "Visual ko"
  no-loop true
  when
    (not
      Message(message==“userVisualOk”, value==true)
      and
      Message(message==“hardwareVisualOk”, value == true)
    )
    $mVisualOk:Message(message==“visualOk”)
  then
    $mVisualOk.setValue(false);
    update($mVisualOk);
end
```

3.4. Profile Management

It works with all the profiles as if they belonged to a single type with regards to the standard. It retrieves the profiles from the cache using the DAO's and decides if they are valid. If they are not valid, it is interacts with the Web Services layer to retrieve the profiles and launch the update process for the cache.

3.5. Data Access Object Layer

It abstracts and encapsulates all the access to the data. DAO [13] layer administers the connection with the data source to retrieve and store data, hiding implementation details inside the DAO's. It paves the way to the possible migration to a different source of data, since in this case only the DAO layer needs to be modified. In addition, it centralizes all the accesses to data in a separate layer.

4. Integration of the CP Module with others EU4ALL and VLE Components

The integration with the EU4ALL modules is based on SOA (Service Oriented Architecture) [6], see Figure 4. This way an open architecture is achieved, easing the changes of processes and the integration of different technologies. This is very important since the functionality of the CP can be invoked from different VLE's and these can be programmed in different programming languages such as Tcl (.LRN), PHP (Moodle), etc … On the other hand, the CP needs to connect to other modules such as User Modeling, Device Modeling and Metadata Repository in a transparent way. The communication protocol used by the CP with the VLE's and the other modules is SOAP (Simple Object Access Protocol). The SOAP protocol wraps the different standards used in the communication. For instance, User Modeling responses to CP with IMS-AccLIP, on the other hand, Device Modeling uses CC/PP in the response, finally, Metadata Repository uses ISO-DRD in the communication with CP. All these standards are understood by the CP and they are translated to facts.

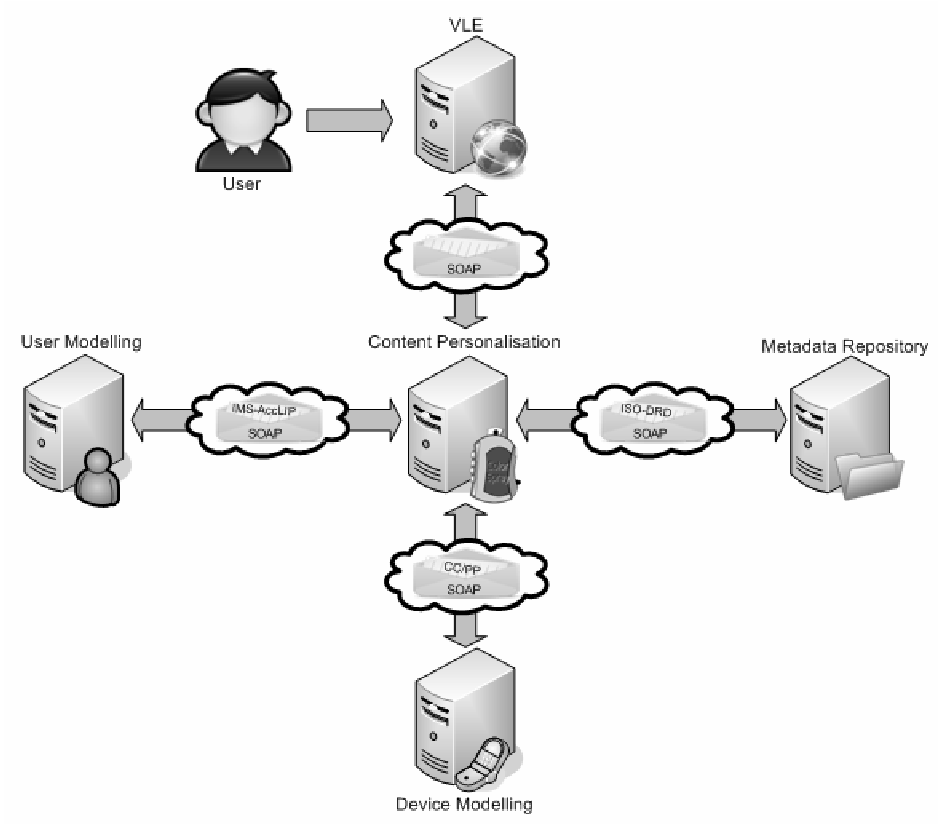

Figure 4. Connection schema between CP and the other modules

5. Conclusions and Future Work

The first prototype of the CP has been implemented with Java 1.5 and allocated in an Apache 5.5.23 web server. An open modular architecture has been created to easily change the profile retrieval, the cache storage and the decision make algorithm using different design patters. The module has been developed using SOA architecture, and as a result the different modules of the architecture are totally independent.

Using a rules based engine in the Decision-Maker component eases the comprehension of the decision making process of the CP and enables to modify the business logic without having to rebuild the module. The structure of the CP allows changing the rules based engine easily.

A graphical user interface (GUI) has been developed for testing purposes of the Expert System. The interface allows creating profiles (users, devices, resources) and to request a personalization for a resource. The figure 5 shows the main page of the GUI. Currently the prototype is under evaluation and the results will be available in late 2009.

A possible root to investigate would be to integrate new standards to the ones already managed by the CP like ISO PNP [16] (Personal needs and Preferences, ISO/IEC 24751-2:2008) which is used to model user preferences and whose integration with ISO DRD is better than the one provided by IMS AccLIP. For the second prototype of the CP it could be possible to conduct a study of the different AI techniques to be used to enhance the performance of the or to substitute the rules based engine with another alternative.

The CP module integrated within EU4ALL architecture will be evaluated on a large scale in European universities at the beginning of 2010. That year the evaluation outcomes will be disseminated and could be checked whether the use of the component is really useful for the students taking into account their needs and preferences.

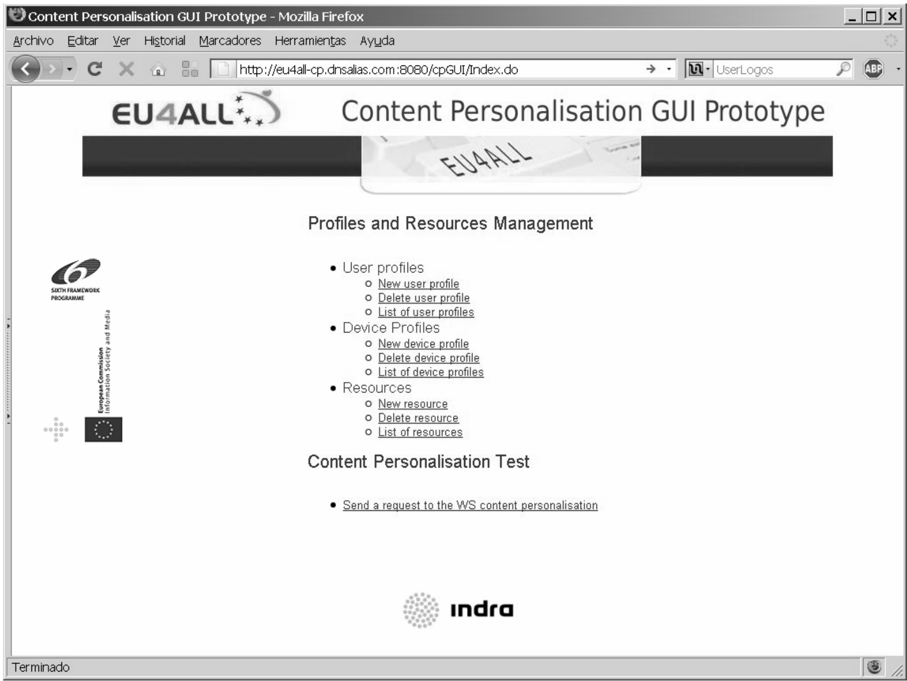

Figure 5. Main page of the GUI for the Content Personalization module

Acknowledgements

The authors would like to thank the European Commission for partly funding EU4ALL project [17] (European Unified Approach for Assisted Life Long Learning - IST-FP6-034778).

References

[1] Pérez de la Cámara S., Fernández del Viso A., Rebate C., Rubión E., Vázquez de Prada E., Gómez N., *Content Personalization: assembling the puzzle of standards*. IADIS Multi Conference on Computer Science and Information Systems (2008), e-Learning Volume II. ISBN: 978-972-8924-58-4, pp. 143-146.
[2] Brusilovsky P., Kobsa A., Nejdl W., The *Adaptive Web: Methods and Strategies of Web Personalization*, Volume 4321/2007, Springer Berlin, ISBN 978-3-540-72078-2, 2007.
[3] Velasco C., Mohamad Y., Carmien S., *Universally Accessible Lifelong Learning by User and Device Profiling Adaptation*, TUMAS-A workshop at User Modelling Conference (2007), pp. 23-26.
[4] Karpouzis K., Moschovitis G., Ntalianis K., Ioannou S., Kollias S., *Web Access to Large Audiovisual Assets Based on User Preferences*, Multimedia Tools and Applications, Vol. 22 Issue 3, Kluwer Academic Publishers, 2004.
[5] Rousseau B., Browne P., Malone P., ÓFoghlú M., *User Profiling for Content Personalisation in Information Retrieval*, 19 Congress ACM SAC (2004).
[6] Newcomer E., and G. Lomow. *Understanding SOA with Web Services*, Addison-Wesley Professional, ISBN: 978-0321180865, 2004.
[7] W3C CC/PP Information Page: http://www.w3.org/Mobile/CCPP/
[8] UAProf in Open Mobile Alliance: http://www.openmobilealliance.org/tech/affiliates/wap/wap-248-uaprof-20011020-a.pdf
[9] IMS AccLIP specification: http://www.imsglobal.org/accessibility/acclipv1p0/imsacclip_infov1p0.html
[10] IMS LIP Specification: http://www.imsglobal.org/profiles/
[11] ISO "Access for all" DRD: http://www.iso.org/iso/catalogue_detail?csnumber=43604
[12] Official page of Axis2: http://ws.apache.org/axis2/
[13] Data Access Object description provided by Sun Microsystems: http://java.sun.com/blueprints/corej2eepatterns/Patterns/DataAccessObject.html
[14] Official page of Jena: http://jena.sourceforge.net/
[15] Official page of Drools: http://www.jboss.org/drools/
[16] "Access for all" PNP: http://www.iso.org/iso/catalogue_detail?csnumber=43603
[17] Official page of the project EU4ALL: http://www.eu4all-project.eu/

Adaptive TEL based on Interaction Traces

Karim SEHABA[a,2] , Benoit ENCELLE[b] and Alain MILLE[b]
[a] *Université de Lyon, CNRS*
Université Lyon 2, LIRIS, UMR5205, F-69676, France
[b] *Université de Lyon, CNRS*
Université Lyon 1, LIRIS, UMR5205, F-69622, France

Abstract. The scientific objective of this work is to develop an Adaptive Technology Enhanced Learning System (TEL) able to observe, by various means, the learner's actions in order to understand his/her behaviour and to response in real time by adequate reactions taking into account people with disabilities. Indeed, in most current computer systems, the interactions between the learner and the system are usually specified by the designer in the conception process and do not take into account the history of the learner and its evolution. The approach we advocate in this work is to use Interaction Traces as Knowledge Sources that can be discovered and exploited by the system. The Interaction Traces here are defined as a history of learner's actions collected, in real time, from his/her interaction with a computer system.

Keywords. Adaptive Systems, Interaction Traces, Technology Enhanced Learning, Accessibility, Disabilities.

Introduction

Adaptive Interactive Systems are characterized by the ability to adapt themselves to the user and use context. Among the factors that motivate this form of adaptation: personalization of interaction, flexibility of use, etc. Traditionally, we distinguish two kinds of adaptation, namely:

- Content adaptation according to knowledge and goals of the user,
- Interface adaptation according to preferences and skills of the user.

The limitations of most existing approaches concern mainly the lack of consideration of cognitive and physical capacities of the user. Indeed, on the one hand, user capacities have a strong influence on his ability to efficiently carry out his tasks. On the other hand, they determine the way in which the user can interact with the system or perceive its state. This information is essential, particularly for taking into account people in "disability situations" and, more broadly, is potentially useful to everyone (eg a person aged, a person in a situation where his hands his eyes are embarrassed or occupied).

In this area, the question we are concerned with is how a computer system can progressively learn from its interactions with users, including people with disabilities. The approach we advocate is to use the Interaction Traces as Knowledge Sources that can be exploited by the system in order to adapt its reaction to users. It consists in generating adaptive scenarios, suitable interaction modalities, personalized interfaces,

[2] {karim.sehaba , benoit.encelle, alain.mille}@liris.cnrs.fr

etc. according to needs, profile and behaviours of each user. The proposed scope of our project focuses in improving TEL accessibility for people with disabilities.

This paper is organized as follows. The next section presents and discusses related work on adaptive systems. Section 2 describes the principle of our architecture. The use of interaction traces for improving adaptive behaviour of system is detailed in section 3. Finally, section 4 presents the conclusion and perspectives.

1. Related work

According to Oppermann [3] a system is called adaptive "if it is able to change its own characteristics automatically according to the user's needs". Adaptive systems consider the way the user interacts with the system and modify the interface presentation or the system behaviour accordingly. So, the adaptive systems receive the information about the user from observations of the user. Several work on adaptive systems, in various application area, have been developed. For example, [6] proposes an Adaptive environment of Interactive Educational Games for Autistic Children, [5] developed Nomadic Radio System that dynamically selects the relevant presentation for incoming mail, voice mail, hourly news broadcasts, or personal calendar events based on message priority, user activity and the level of conversation in the environment. NetCoach system [8] provides a way to assess the users' prior knowledge and to adapt the course in different ways.

In these systems and in the majority of existing approaches, the architectures basically consist of three main components as pointed out by [9]:

- The user model represents the system's beliefs about the user (learner model, profile model, psychological model…),
- The domain model defines the aspects of the system and the world that are important for inferences, e.g., functions that might be altered.
- The interaction model handles the dialog between the user and the application.

However, to our knowledge, there is no model that proposes an adaptive approach, based on Interaction Traces, which takes into account the history of the user and his evolution. The history is a diary of activities suggested by system and the results carried out by user. It allows tracking of the evolution of the user and is also at the origin of many rules of decision.

2. General architecture

The figure 1 shows the general architecture of the system. Initially, the expert feeds the system with the domain knowledge. It is a set of scenarios related to the training objectives. Thus, this knowledge and the user profile will be used, in a reasoning process based on Case-Based Reasoning [6], to generate an adaptive learning scenario taking into account the suitable interaction modalities. For example, the system can read a text for blind people, enlarge the font size for visually impaired people, etc.

During the interactions between the user and the system, all the user actions are stored in an Interaction Traces. A Traces Management System (TMS) uses in real-time these traces as sources of knowledge in order to control the scenario execution. TMS allows also using interaction traces to update domain knowledge and user profile, which are represented by a Dynamic Bayesian Network.

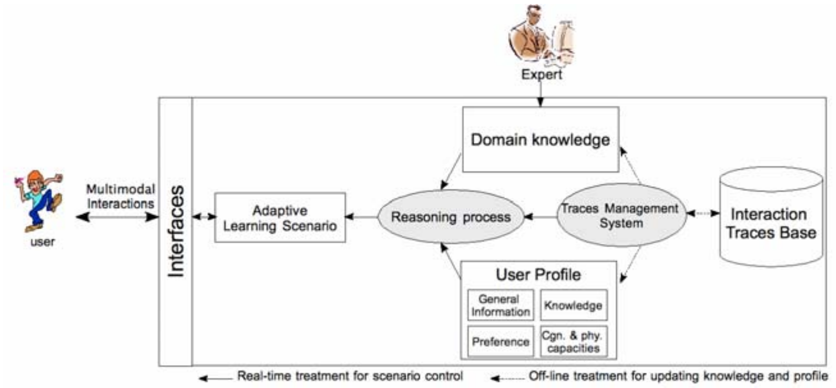

Figure 1. General architecture

The idea of our approach, based on *k-means* clustering algorithm, is to update the structure of the Bayesian Network (BN) by analyzing the values of observed variables (the evidence variables of BN) in order to create/modify node(s) or relation(s) between nodes.

3. Adaptive behaviour based on Interaction Traces

The scientific objective here is to illustrate the close links between the Interaction Traces and Knowledge Discovery in the adaptive systems area. In this section, the transition from interaction traces to knowledge discovery is studied in depth and we present mechanisms used for personalizing user interfaces using multimodal interactions.

3.1 From traces to knowledge discovery

The Interaction Traces are defined as a history of learner's actions collected, in real time, from his/her interaction with a computer system. Formally, a trace is represented by a sequence of observed values generated from the interaction user-scenario. The scenario is a set of observable nodes generated by reasoning process from Bayesian Network.

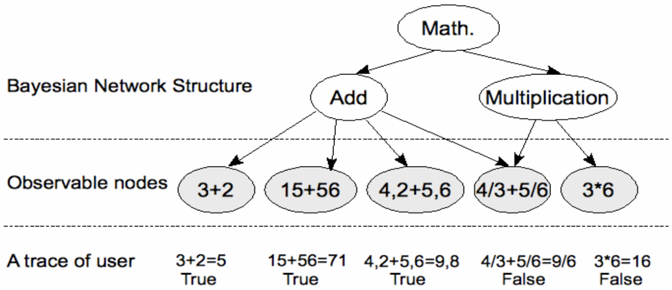

Figure 2. Example of Bayesian Network and interaction trace

The Interaction Traces of each user can be used by the system in order to adapt the learning scenario to the user and also to update the knowledge domain and the user profile. The figure 2 shows an example of a Bayesian network and the corresponding trace. The analyse of the trace of the user allows, on the one hand, to draw conclusion on the user profile concerning the basic arithmetic operations. On the other hand, the reasoning process can generate exercises more difficult on addition and other activities that explain the multiplication.

These interaction traces can also be used by the user for analyzing his productions (See for example [1]). By doing this, we add a reflexive dimension to the user's activity, intended to help him apprehending its environment, making a better usage of it, and then improving the productivity of its activity.

3.2 Multimodal user interfaces for improving systems accessibility

According to Oviatt [4], multimodal interfaces have the potential to accommodate a broader range of users than the traditional interfaces. As a result, providing to the users systems with fine tailored, personalized multimodal interfaces will improve systems overall accessibility, all the more for people with disabilities [7].

The difficulty of taking into account multimodal interfaces, in Adaptive Interactive systems area, is mainly due to the choice of appropriate modalities, i.e. that best suit cognitive and physical capacities of the user. To do this, we plan to use special mechanisms for setting user preferences (see [2] and ISO/IEC 24751-2:2008 [3]) according to the type of educational content that can be specified using ISO/IEC 24751-3:2008[2]. Generally speaking, it consists in comparing the properties of each modality with cognitive and physical capacities of the user in order to detect possible incoherence and to determine the preferred interaction modalities. For example, the presence of a disability that affects ability to use the computer with a gestural mode of interaction, or visual impairments that require the use of screen readers, etc.

Interaction traces are used here to adjust user preferences, detecting the habits of the user concerning content presentation, content scanning, etc. Concerning presentation for instance, if a user, with a given visual impairment, often zooms in to enlarge size of specific fonts, system analyse of these interaction traces can result in a better adjustment of fonts or/and font sizes that will be used. Moreover, the system in some cases can suggest a bimodal presentation of the content, e.g. a visual presentation and an audio presentation.

4. Conclusion

This paper presents an approach of adaptive TEL based on Interaction Traces. It consists in taking into account the history of the user’s actions in order to adapt in real-time the system reaction, particularly, the learning scenarios and user interfaces using multimodal interactions.

The proposed representation of interaction traces allows to update the knowledge domain and user profile that are represented using a Dynamic Bayesian Network. The idea of the approach is to use *k-means* clustering algorithm in order to update the Bayesian network structure.

[3] http://www.iso.org/

The first obtained results by simulation are interesting and promising. However, more experiments are needed to validate the proposed models and architecture, particularly a TEL environment area.

Future works include the verification of the scenarios coherence. Indeed, the adaptive scenarios may cause some inconsistencies in the overall logic of the learning session.

References

[1] D. Cram, D Jouvin, A. Mille. *Visualizing Interaction Traces to improveReflexivity in Synchronous Collaborative e-LearningActivities*. 6th EuropeanConference on e-Learning, AcademicConferences Limited ed. Copenhaguen. pp. 147-158. ISBN 978-1-905305-57-. 2007.

[2] B. Encelle, N. Jessel. Personalization of User Interfaces for Browsing XML Content Using Transformations Built on End-User Requirements. *International cross-disciplinary conference on Web accessibility*, ACM International Conference Proceeding Series, Vol. 225, 58-64, 2007.

[3] R. Oppermann. Adaptivelysupportedadaptability. *International Journal of Human Computer Studies*, 40(3), 455–472.1994.

[4] S. Oviatt, Multimodal interfaces. The Human-Computer Interaction Handbook. Lawrence Erlbaum Associates, Mahawah, New Jersey, USA, 286–301, 2003.

[5] N. Sawhney, C. Schmandt. Nomadic Radio: Speech & Audio Interaction for Contextual Messaging in NomadicEnvironments. *ACM Transactions on Computer Human Interaction* (ToCHI) on the topic of Human Computer Interaction and Mobile Systems. 7 (3), pp. 353–383. 2000.

[6] K. Sehaba, P. Estraillier, D. Lambert. *Interactive EducationalGames for AutisticChildrenwithAgent-Based System*. 4th International Conference on Entertainment Computing (ICEC'05), number 3711 in Lecture Notes in Computer Science (LNCS), pages 422–432, Springer. September 2005, Sanda, Japan.

[7] H.S. Vitense, J.A Jacko and V.K. Emery. Multimodal feedback: establishing a performance baseline for improved access by individuals with visual impairments. In: Fifth Annual ACM Conference on Assistive Technologies, pp. 49-56, 2002.

[8] Weber, G., Kuhl, H.-C., and Weibelzahl, S. *Developing adaptive internet based courses with the authoring system NetCoach*. In Proceedings of the Third Workshop on Adaptive Hypermedia, AH2001, 2001.

[9] S. Weibelzahl, *Evaluation of Adaptive Systems*.Ph.D. Thesis, University of Trier, Germany, October 2002.

Empowering disabled people: e-learning challenges for independent life

Carmen Barrera [a], Olga C. Santos [a], Emmanuelle Gutiérrez [a], Jesús G. Boticario [a], Javier Moranchel [b], Jose R. Roldán [c] and Roberto Casas [b]

[a] *aDeNu Research Group. Artificial Intelligence Department*
Computer Science School, Spanish National University of Distance Education - UNED
{carmen.barrera, ocsantos, egutierrez, jgb}@dia.uned.es, http://adenu.ia.uned.es
[b] *University of Zaragoza*
[c] *ATADES Association*

Abstract. This paper presents a solution to address the technological challenges to support the needs of people with intellectual disabilities towards an independent life, in the scope of the CISVI research project, which proposes a new research methodology to deal with the needs of disabled and social communities.

Keywords. CISVI, ESdI, independent living, inclusive learning

Introduction

Research in Advanced Learning Technologies (ALT) could have a direct impact on the improvement of the quality of life (QoL) of disabled and non-disabled people. QoL represents the degree to which an individual can establish and sustain a viable self in the social world [1]. However, technology is very often not ready to support the final user in this way.

In this context, at the aDeNu group we are doing advanced research on the Information and Communication Technologies (ICTs) to foster the inclusion into the society of people with cognitive and physical disabilities. At present, we are involved in the CISVI project (TSI-020301-2008-21), which faces different issues related to the inclusion of the disabled people using the ICTs.

This paper addresses the challenges to help people with intellectual disabilities (PID) in easily learning the activities of daily living (ADL).

Research Communities for Health and Independent Living

The main goal of the *Research Communities for Health and Independent Living* (CISVI) project is to identify, test and validate a new methodological research framework named *Social Spaces for Research* (ESdI) in three scenarios: i) labour integration of people with cognitive disabilities (ESdI1), ii) home healthcare for elderly people (ESdI2), and iii) living independently (ESdI3).

The research activity carried out within the scope of these three ESdIs pose important contributions in the following areas of technology and its adaptation for elderly or to people with some kind of physical or intellectual disabilities:

- Intelligence Environmental Technologies: RFID, mobile sensors, etc.
- Mobile devices for accessing ICT suitable for meeting the needs of people with disabilities and dependence
- Accessibility, usability and user modelling technologies
- e-learning and e-mentoring ubiquitous technologies, adapted to people with disabilities and dependence
- Tracking and geographic information technologies
- IT security and identity

The primary objective of ESdIs research framework is to encourage the involvement -from the very beginning of the research activities- of the end user as co-creator of the services [2].

In this paper, we are focusing on discussing how Esdl3 is addressing independent life improvements of PID. Elsewhere it is described the Esdl1 approach, where adaptive e-learning and e-mentoring to support people's work integration is provided in terms of recommendations [3].

EsdI3 Scenario: living independently

The educational scenario is located at the ATADES-Santo Angel[4] occupational centre for adults in Zaragoza, Spain. This centre has a long experience, and takes in people with heterogeneous intellectual disabilities for their long life learning. It offers training on general and social abilities, workshops, therapeutic activities, physical exercises and handcraft works for commercial companies. The goal is to facilitate the integration of PID into the community. Currently, about 200 people, ages ranging from 21 to 65 years old, with an average of 40, are in the centre. The professional team includes educators, psycho-pedagogues and managers.

The investigation on key technologies aims to promote independent living for elderly and disabled people with the least possible assistance. According to the law of dependence [4], different technological supports need to be provided:

- Educational support for learning basic daily life activities (health and hygiene, autonomy in food, dress)
- Educational support for learning instrumental daily living activities (cooking autonomy, home order and cleanliness, using the telephone)
- Educational support for learning advanced daily living activities (eating habits, food choices, make a shopping list, communication, leisure, tasks management, orientation, mobility)
- Personal Safety support:
    - Detection of risk situations focusing on the individual person: fall detection, abnormal behavior (for example, a long time without getting out of bed), etc.
    - Risk detection focusing on the setting: cold / heat (for example, because of a window which has been left opened) fire, smoke, etc.

4 ATADES - http://www.atades.org/

- o Detection of risks which may come from an external situation such as burglary; abnormal presence detection.

The first experience supports the ADL of washing-up the hands. A touch screen hanged on the bathroom wall displays the sequence of steps to follow the activity.

Figure 1. The “how to wash your hands, step by step” lesson

The use of the ALT has a twofold impact, i) as a complement to empowering personal capabilities (abilities) and ii) as a tool for professionals that facilitates the follow-up of the global process. The goal of the training is the acquisition of abilities for daily independent living, but, depending on each person and the nature of their disability, ALT can contribute to:

- Recalling in a continuous life-long learning process
- Reinforcement for achieving trust in one self
- Support for reducing their dependency level
- Independent living, with the acquisition of the learned ability

Supported Technology

Educational supports are based on educational units in which different contents are presented, such as:

- Videos of different daily activities in which different disabled people are performing daily tasks. These videos help to reinforce activity learning.
- Audio with tasks carried out in the different stages of daily activity.
- Images with pictures of disabled people executing these tasks. These images are complemented by iconography, based on augmentative language, according to the user-centered design principles.

Devices which contain this interface consist of tactile screens with Wi-Fi connection, adapted interfaces such as: a switch adapted mouse, a virtual mouse, etc

It should be noted that all the contents are shown according to the location of the user, by using location systems.

On the other hand, personal safety support is based on ICTs, such as: location systems, movement and presence sensors, flood and smoke detectors, actuators, etc.

Activities during the project life cycle

Within the project there are several phases in which successive iterations of short-term working periods evaluate the results within its phase, in order to improve the technological solutions and find new sustainable ways to perform the solution.

As a result of the sustainable development of the ESdI, results will be shared within an open community of users and will be extended to other associations and related foundations.

The project is in the first 6 months of its development, and has achieved:

- The development of a technological support for teaching and learning basic daily activities such as "how to wash your hands, step by step". ATADES Association, UNED[5], FZCC[6] Foundation and University of Zaragoza[7] have taken part in this interface development
- A survey and evaluation of accessibility and usability of the interface with the assistance of the ATADES multidisciplinary team, which suggested improvements.

Currently, the evaluation of the interface with real users is being conducted at ATADES-Santo Ángel Occupational-Centre.

It is planned that the ESdI evolves as follows until 2011:

- Continued development of the interface in ATADES-Santo Ángel Occupational Centre, extending it to other activities (educational support for learning basic and instrumental daily living activities).
- Support for independent living in the residential centres of the ATADES association.
- Support for independent living in private homes and supervised apartments.
- Support for independent living in flats of Valdespartera.

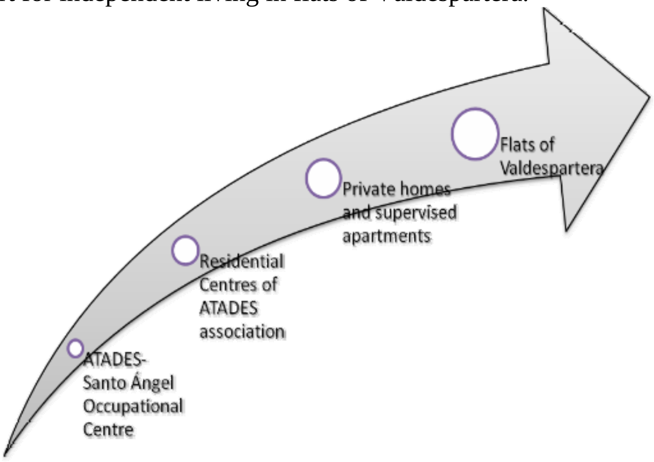

Figure 2. The ESdI-3 life cycle

[5] Spanish National University of Distance Education - http://www.uned.es/
[6] FZCC - Foundation Zaragoza City of Knowledge - http://www.fundacionzcc.org/
[7] University of Zaragoza - http://www.unizar.es/

Needs and Challenges

In order to understand the needs of PID and provide some technological solutions to address them, we have carried out observational sessions at the occupational centre and had interviews with the professional team.

After this process, the main conclusions we have gathered are:

- Once PID are given some guidelines for working, they follow them without exception.
- PID require additional effort to modify a learnt guideline (i.e. their capability to adapt to the environment is limited)
- PID require alerts and reminders of the activities at each time.
- Professionals look after the tasks and check if they have been carried out successfully.

In this context, a set of challenges for the ALT appear to address functional diversity of PID:

- Differences in user-agents (e.g. browsers) should be transparent to the users
- Multi-media resources should be offered
- Multi-modal interaction should be provided
- Heterogeneous learners' cognitive levels should be taken into account
- Contents and presentation should be adapted for each learner according to the learner's features (i.e. learner profiles managed by user modeling techniques)
- Contents have to be frequently and continuously updated to cope with the changes in the environment and the processes
- To facilitate the continuous updating, educators need to have a repository of learning objects conveniently marked with the metadata for the user profile of each student.
- Educators also need an editor accessible and usable to provide a quick update.

Solutions at the CISVI project for Esdl3

The solution offered during the first stage of the project consist of: i) elaborating the template with the sequence of steps corresponding to a particular activity, ii) developing the learner profile, which includes the personal features that constrain the learning process, iii) selecting 6 PID from the occupational centre and describing their profiles, iv) specifying the most adequate tutorial for each one, v) developing each tutorial and vi) documenting the whole process for adapting contents and their presentation to the learner's needs.

The elaboration of the template was a process shared between the technological and educational partners, following a process of creation and revision.

Each step of the template is a web page that incorporates multiple resources in different media (text, image, audio, video and iconography for augmentative communication). Moreover, the template includes different options for presenting the information, regarding colours, position of items in the screen, or navigation icons. Figure 1 shows the first slide for the washing-up hands activity. The navigation between the steps can be done by multiple modalities: mouse, keyboard, voice, tactile interaction, physical button or a time deadline.

This scenario requires a level of extreme personalisation to facilitate the complete adaptation of the resources to the individual: each user interacts with their own images and videos performing the activity; the time deadline for the automatic navigation is adjusted to the user pace on each step of the activity; the audio is the known voice of the educator; images identifying locations are from the real scenarios.

This extreme personalisation of the solution poses the following challenges:

- ALT need to include a repository of media resources with metadata that relates each media to the user or group of users, and from the template and the search on this repository generate the lesson for each user.
- Facilities to support adaptations provided by the educator, thus the system needs to be flexible, configurable; it needs to provide the tools that facilitates the educator the easily modication of the application objects.
- Tracking user's interaction and providing recommendations from the recommender system. Several recommendations can be provided. For instance, advising the educator for configuring some parameters (e.g. the adjustement of deadline times for each step of each people).
- The cost of building and deploying all media resources is very high.

To date, experiences have been performed with 6 people. First, the activity was performed in a natural way; next the activity was repeated using the guide of the educator, and finaly with the use of the deployed technology. The experiences were recorded and analysed, so that conclusions can be drawn to improve the process. The experience proves the importance of the user-driven approach. Some of the developed enhancements are as follows:

- New steps included in the process.
- Detection of lack of recognition for some pictures (i.e. image with the name of a location replaced by the location itself)
- Different deadline times for each user
- The attention is centred on the audio more than on the image

Conclusions and future works

From our experience in the CISVI project, we have come to the following conclusions:

- The individual differences of each user have to be taken into account from the ouset.
- Combining design for all approaches with personalization features provide solutions that are able both to comform different types of needs from the design viewpoint and support their adaptation to the specific needs of the user while the interaction takes place.

Future works deal with several cycles of experimentation and refinement, extension to other ADL, introduction of mobile devices, and dynamic support through recommendations.

Acknowledgements

Authors would like to thank the Spanish government for funding the CISVI project (TSI-020301-2008-21).

References

[1] Brown I., Brown R., Quality of Life and Disability. An Approach for Community Practitioners, Jessica Kingsley Publishers, ISBN 1843100058, Jun 2003.
[2] Tansey M., Stembridge B. The challenge of sustaining the research and innovation process, World Patent Information, 27 (3), p.212-226, Sep 2005
[3] Santos, O.C., Couchet, J., Boticario, J.G. 2009. Personalized e-learning and e-mentoring through user modelling and dynamic recommendations for the inclusion of disabled at work and education. ICALT 2009 (in press).
[4] Spanish Dependency Law 39/2006 of December 14, Promotion of Personal Autonomy and Care for people in a situation of dependency.

Adapting an educational tool to be used by non-severe cognitive disabled students

Diana Pérez-Marín, Ismael Pascual-Nieto and Pilar Rodríguez
Computer Science Department, Universidad Autonoma de Madrid

Abstract. Since 2007, we have been using the Will Tools, a set of Blended Learning applications able to automatically assess students' free-text answers and provide immediate personalized feedback to each student. In this paper, our hypothesis is that these tools can be easily adapted to be used by students with some type of non-severe cognitive impairment. In order to test this hypothesis, we present a procedure to transform the Will Tools into the Will Tools ALADE (the version of the Will Tools designed for students with cognitive disabilities). Moreover, an experiment in which 13 students, some of them with Down syndrome and others type of non-severe mental disabilities, have successfully used the Will Tools ALADE is described.

Keywords. Blended learning, free-text assessment, Natural Language Processing, cognitive disability, Down syndrome.

Introduction

In the last decades, there has been a revolution in the field of the New Technologies for Information and Communication. The lower prices of the computer equipments and the greater number of computer applications have favored a change in the use of computers. In fact, computers are not longer regarded as complex tools just for Computer Science people, researchers or engineers, but useful tools for a great majority of the population.

10% of the world population has some kind of disability [1]. They should not be excluded from the new technologies. On the other hand, they can benefit, even in some cases more than people without any disability from the use of the new technologies to get more integrated in the society.

People having a disability are not longer regarded just as ill people to marginalize into hospitals, but as people to be integrated in the society. Therefore, computer applications should be designed according to the Universal Design to be used not only by impaired people but by everyone [2,3,4].

The new technologies help people with some kind of impairment to improve their quality of life. The role of computers in achieving this goal is helping as a facilitating tool. Currently, there is a wide number of available computer applications for several types of impairment. Many of them are free and they can be downloaded from Internet. Some of them even offer their code so that programmers can offer an improved version of them to the community.

A great percentage of these computer applications for the attention to diversity are based on the idea of multimodal information redundancy. That is, they present the information not only graphically, but also in other media such as sound or haptic information. That way, people with visual limitations can still access the information of a document.

Graphical interfaces and visual stimuli has also benefited other types of disabilities such as autism. In fact, it has been claimed that autistic children interact better with those new environments [5].

People with hearing difficulties could be considered one of the most benefited collectives because the available information is usually visual. This is the reason why there are less computer applications developed to improve their accessibility to information. On the other hand, they can also take advantage of tools to communicate via text such as electronic mails, chats and specific programs designed to call by text.

Physically disabled people can also get benefited from the new technologies to access information designed to overcome their limitations. For instance, tetraplegic people can work from home interacting with the computer with eye screeners or special buttons to use virtual keyboards instead of physical ones.

In this paper, the focus is placed on people with cognitive disabilities such as students with Down syndrome, or with some type of mental disability. In particular, our hypothesis is that Artificial Intelligence in Education (AIED) tools such as the Will Tools can also be adapted to be used by people with non-severe cognitive disabilities (i.e. people that can still talk, read and write but at a lower pace or with assistance).

The Will Tools are a set of Blended Learning on-line tools [6]. Blended Learning or Hybrid Learning tools combine traditional teaching methods with the application of computer applications for education. That way, it is possible to take advantage of the benefits of e-learning without bearing its disadvantages [7]. For instance, students can review their lessons after class, and teachers can monitor their students' progress.

These tools have been used with positive results in our home university since 2007, both in technical and non-technical domains, and by students with and without technical training (i.e. knowledge in how to use computers and computer applications) [6,8,9]. Therefore, we would also like to develop a version of the tools that could be used by people with cognitive disabilities, so that they can take advantage of the benefits of these web-based learning systems.

We asked a group of our home university, who teach to students with Down syndrome and other types of mental disabilities, for their opinion about which changes should be made to adapt the Will Tools to a version that could be used by their students too.

They provided us with a list of changes, and offered us the possibility of testing the new version of the Will Tools, that we called Will Tools ALADE, with their students. That way, we came up with a procedure to adapt Blended Learning tools to people with non-severe cognitive disabilities, and we implemented it in Will Tools ALADE (Atención a LA DivErsidad, attention to the diversity).

In December 2008, we tested the Will Tools ALADE with a group of 13 students with Down syndrome and mental retardation, and they could successfully use them, supporting our hypothesis.

The paper is organized as follows: Section 1 outlines the main features of the Will Tools; Section 2 focuses on the Will Tools ALADE version; Section 3 describes the experiment performed; and, finally Section 4 ends with the main conclusions and lines of future work.

1. The Will Tools

The Will Tools are accessible on-line at http://orestes.ii.uam.es/willtools, and consist of four subsystems: Willow (the student tool), Willed (the authoring tool), Willov (the teacher tool), and Willoc (the administration tool).

Willow is an automatic and adaptive free-text scorer system. It is able to provide feedback adapted to each student according to his or her answer written in natural language (in Spanish or in English). Figures 1 and 2 show a sample of question-answer interaction in Willow.

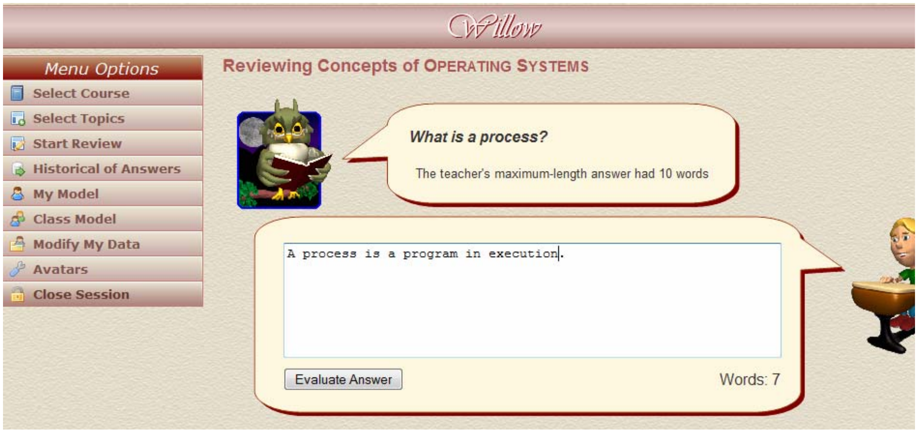

Figure 1. Sample snapshot of Willow asking a question to the student.

Figure 2. Sample snapshot of Willow providing feedback to the student.

As can be seen in both figures, the metaphor of a dialogue between the system and the student is followed. The system is represented by an owl as its avatar, and the student can choose its own avatar from the gallery of available avatars.

In this paper, it is not explained the process of automatically evaluating the students' free-text answers, or how to generate a conceptual model indicating which concepts should be reviewed (*My Model* and *Class Model* options in the menu) as both topics are out of the scope of this paper, and already published elsewhere [10].

However, it is important to mention that the core idea for the automatic assessment of students' free-text answers is the comparison between the student answer and one or more correct answers provided by the teachers. In this way, the more similar the student answer is to the correct answers provided by the teachers, the higher the score that is provided to the student.

Willed is an authoring tool in which teachers can create courses to be delivered in Willow. The courses can be created by interacting with Willed, or just uploading a plain text template with the content of the course.

The template should contain the name of the course, a brief description, the language of the course, and per each lesson of the course a set of questions. For each question, it should be provided its statement, maximum score, level of difficulty and one or more correct answers written in plain text.

Willov is a monitoring tool in which teachers can keep track of the performance of their students with Willow. Moreover, they can look at automatically generated graphics showing when the students have accessed Willow, how many questions they have answered and how long they have reviewed.

Finally, Willoc is an administration tool in which it is possible to enroll or remove students in courses and manage the students' data.

2. The Will Tools ALADE

As can be seen from Figures 1 and 2, although the interface has been designed using Human-Computer Interaction principles so that it is simple, user-friendly, consistent and no student without cognitive disabilities has difficulties using it, it still has some options that could be complex to use by students with some type of cognitive disabilities. For instance, the menu, which has many different options.

In the meeting with the group of experts in teaching people with some type of cognitive impairment, they advised us:

- To simplify the interface so that the options of the menu that are not completely necessary are removed.
- To add more focus on the dialogue between the system and the student.
- To make answering the questions easier, especially as writing text into the computer may be really difficult for people with cognitive disabilities.
- To be constant in all interfaces so that once students know how to use some element in the interface, they do not have to keep learning new elements.
- To avoid taking into account the orthography of the sentence as the goal was to assess the content, and these students tend to have many problems writing the words with a correct orthography.

We applied these guidelines to transform the Will Tools, especially Willow which is the student tool, into the Will Tools ALADE in less than a month-time of programming. The tools are also available on-line at http://orestes.ii.uam.es/alade/

Figure 2 and 3 show the new interface adapted to be used by any student in Willow ALADE for a question-answer interaction. The interface is in Spanish as there are no English courses in the system.

As can be seen the menu has been removed as the options included in it have been moved to other systems of the Will Tools ALADE, or removed. For instance, the model options have been removed as in the current version of the system are considered too complex, and the modification of data, selection of topics and course have been moved to the monitoring tool so that teachers are now in control of these choices.

The dialogue between the system and the student occupies now nearly all the screen, and the student is given the possibility of looking at different possible answers to the question by clicking on the help icon (i.e. the red question mark next to the evaluation button). Only one of the possible answers provided is correct. The student has to choose which one is, and to type it into the text area to answer.

It is also important to highlight here that this version of the tools meet the aforementioned Universal Design principle. As it has been designed thinking that can be used by all students. That is, given the focus on the dialogue and by providing hints, it is expected that can be used by students with Down syndrome, or some type of mental disorder, but also by children or adult students without any mental disability.

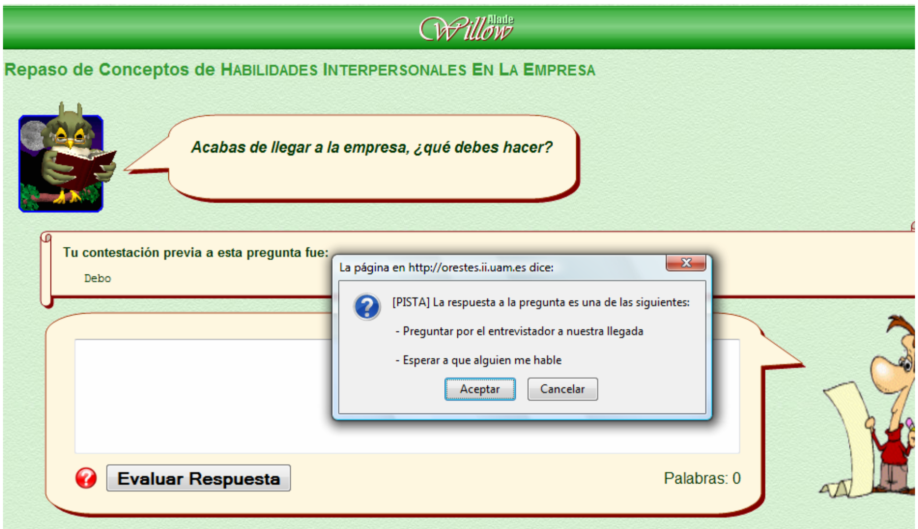

Figure 3. Sample snapshot of Willow ALADE asking a question to the student (the question translated from Spanish into English is “what should you do if you arrive late for a job interview in a company?” and the answers shown are: “To ask for the interviewer when we arrive.” or “To wait until someone talk to us”) .

Figure 4. Sample snapshot of Willow ALADE providing feedback to the student (the answer translated from Spanish into English is "To ask for the interviewer when we arrive").

Whenever a student click on the "Evaluate answer" button, the feedback page is generated as in Willow. However, the difference is now that the self-assessment feature is removed, as it is no longer necessary. Given that the student writes one of the possible answers from the list provided, the assessment of the answer does not have any difficulty, as it is just a comparison between two sentences that should be equal to pass the question (taking into account that no penalization should be applied because of bad orthography as the teachers advised us).

It can also be noticed that the feedback page has been simplified, so that the correct answers are no longer shown separated from the qualification, but they appear in the same note. Moreover, a graphical help has been provided so that the students only need to look at a face: happy in case they have passed the question, sad otherwise.

Willow ALADE keeps asking questions that have been failed until the student is able to pass them (a feature that the teachers want to keep from Willow).

3. The experiment

In December 2008, we asked the teachers, experts in cognitive disabilities, to test Willow ALADE with a group of their students. They allowed us to go to one of their classes, as it was the first experiment in which Willow ALADE was going to be used. They also told us that although the idea was that students try to use Willow ALADE on their own, they will be in the class in case that we need their help.

Moreover, the teachers helped us into choosing which topic should be the more interesting for the course of the experiment. They told us that a course about social skills would be helpful as these students have problems with situations such as job interviews or how to react in new situations. It was estimated that students could pass this course in 2 hours as it has 15 questions, and to pass the course it was necessary that the students pass at least half of the questions (about 15 minutes per question).

They gave the content of the course to us as previously explained in Willed (it does not change for the ALADE version of the Will Tools), and the data of 13 students, some of them with Down syndrome and the rest with mental retardation. These students were chosen by the teachers to be the first students in using Willow ALADE. They were chosen because they did not have a severe cognitive impairment, that is, they were able to turn on a computer, use a keyboard to type and a mouse to point into the screen, and interact with simple options in text processors (e.g. to write a letter).

Given that Willow ALADE is an on-line application the students could use the system from their computer lab. First of all, we gave a 5-minute talk explaining the goal of the system, without explaining the interface in detail.

After that, the students started using the system during two hours with our supervision and the supervision of their teachers. Most of them did not find any difficulty into using the system, and they only asked questions about the content of the questions. In fact, 6 out of the 13 students (46%) were able to pass the whole course in less than the 2 hours that we have estimated, and 11 out of the 13 students (85%) completed the course in time.

One of the students who was unable to complete the course was because he had to leave the class; and, the other student was because he has the more severe cognitive impairment. He needed our help to understand the mechanism of the system, and once he was able to understand what he had to do, he needed help to type the answers as it was too complicated for him to remember the sentence and type it again in the text area.

Figure 5 shows a snapshot of Willov ALADE interface in which the teacher can see the progress made by the students. As can be seen, the percentage of questions that the student has tried and the percentage of questions that s/he has managed to pass appears next to the name of each student (removed for privacy reasons). The same information is also graphically displayed with a bar in which the green part indicates the questions that have been passed, the red part indicates the questions that have been tried but not passed, and the grey part indicates the questions that have not even tried.

The last column is not used in this case because all students belong to the same group, but if the teachers had classified them into several groups, the label of the group to which each student belongs would appear here.

We also asked the students to write their individual opinion about the system (especially focusing on which feature they have enjoyed the most and what they would like to change). Some of the sentences that the students wrote are:

- “I have enjoyed this class very much, the questions were very good and I have enjoyed the program”.
- “What I have liked the most is the topic of the questions. That way, we can get a job. Thank you for helping us to get a job”.
- “What I like about the program is some questions, but other questions are a little difficult and I did not know to answer them. The help icon is good because if you do not know how to answer, it helps you”.
- “I have enjoyed this class very much as it has been fun”.

We were surprised to notice that not only the students were able to correctly use the system and pass the questions of the course, but they seemed to like it, and some of them even claimed that they have found it a funny way to interact with the computer.

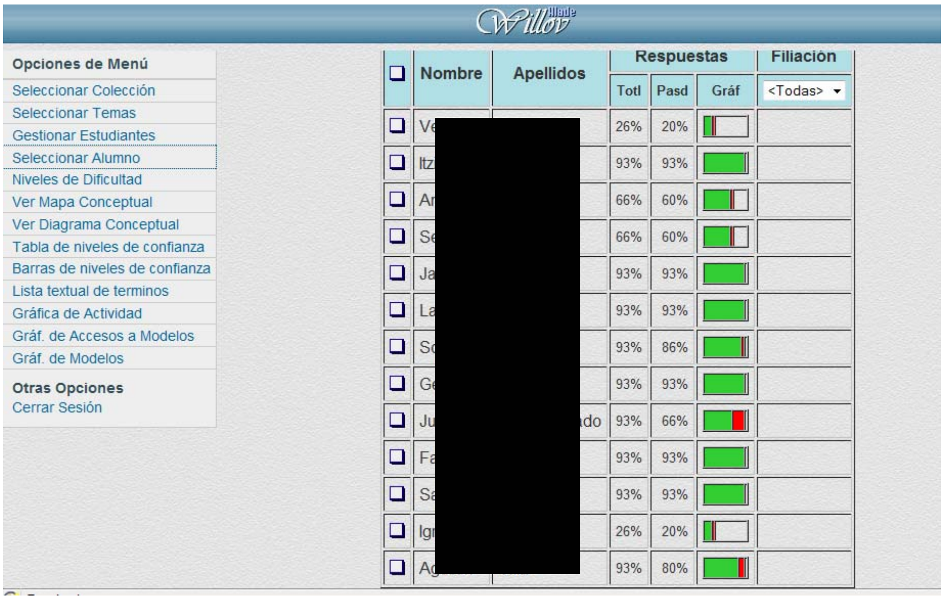

Figure 5. Sample snapshot of Willov ALADE with the progress made by the students

4. Conclusions and future work

In this paper, our hypothesis that the Will Tools, a set of Blended Learning tools able to provide automatic and adaptive feedback to each student from their answers written in natural language, could be adapted to be used by students with some type of non-severe cognitive impairment, has been supported.

We asked the opinion of a group of teachers expert in students with cognitive disabilities, and they provided us with a list of changes to transform the Will Tools into the version Will Tools ALADE. The implementation of these changes was quite easy, and in less than a month programming time the new version was built.

The Will Tools ALADE were used by 13 students, some of them with Down syndrome and others with mental retardation, and except for two students (one who had to leave the class, and other who considered the task too complex), the rest of them were able to complete the course with Willow ALADE without any difficulty.

As future work, we would like to repeat the experiment with more students and a control group to be able to do a more complete statistical study of the data gathered.

Acknowledgment

This work has been sponsored by Spanish Ministry of Science and Technology, project TIN2007-64718.We would also like to thank Dr. Dolores Izuzquiza and her group for her invaluable help in the design of the Will Tools ALADE, and for letting us test the system with her students. Last but not least, our thanks for the students who have volunteered to use the system.

References

[1] R. Lorenzo & L.C.P. Bueno, *Tratado sobre discapacidad*, Thomson, 2007.

[2] V. Iwazaki, Fujitsu's Activities for Universal Design, *FUJITSU Sci.Tech.* **41** (2005), 3-9.

[3] Vodafone, *Tecnologías de la Información y Comunicaciones y Discapacidad*, Fundación Vodafone España, 2005.

[4] D. Archambault, R. Ossmann, T. Gaudy & K. Miesenberger, Computer Games and Visually Impaired People, *Upgrade (*2007).

[5] L. Pérez-de-la-Maza, Programa de estructuración ambiental por ordenador para personas con trastornos del espectro autista: PEAPO, *in 'Actas del XI Congreso Nacional de Autismo'*, 2005.

[6] D. Pérez-Marín, I. Pascual-Nieto, E. Alfonseca, E. Anguiano, & P. Rodríguez, P. A study on the impact of the use of an automatic and adaptive free-text assessment system during a university course, *in 'Blended Learning*', Prentice Hall, Pearson Education, 2007.

[7] C. Graham, *The Handbook of Blended Learning: Global Perspectives, Local Designs*, Pfeiffer, 2006.

[8] I. Pascual-Nieto, D. Pérez-Marín, M. O'Donnell & P. Rodríguez, Enhancing a free-text Adaptive Computer Assisted Assessment system with self-assessment features, *in 'Eigth IEEE International Conference on Advanced Learning Technologies*', 2008.

[9] I. Pascual-Nieto, D. Pérez-Marín, P. Rodríguez & M. O'Donnell, Using Automatically Generated Students' Clickable Conceptual Models for e-tutoring, *CEUR-WS* **354** (2008), 1-8.

[10] D. Pérez-Marín, *Adaptive Computer Assisted Assessment of free-text students' answers: an approach to automatically generate students' conceptual models*, PhD thesis, Escuela Politecnica Superior, Universidad Autonoma de Madrid, 2007. Available on-line at http://orestes.ii.uam.es/dperez/tesisDianaPerezMarin.pdf (link checked on 04/09/2009).

Adaptive Evaluation Based on Competencies

Beatriz E. Florián G.[a,b] , Silvia M. Baldiris [a] and Ramón Fabregat Gesa [a]
[a] *Institute of Informatics and Applications (IIiA), University of Girona, Spain*
[b] *Escuela de Ingeniería de Sistemas y Computación, Universidad del Valle, Colombia*

Abstract. The lifelong competence development and transfer of competencies acquisition is a tendency of global world and specifically for e-learning.. Generally, an instructional based-competence process consists in four single sub-processes, the competence definition, competence development, competence assessment process and certification. This paper presents a competence-based adaptive assessment process for judging competence of learners in the context of a virtual learning environment. The goal of our research is build repositories of items linked to competencies definitions and rules specifications in order to the generation of adaptive evaluation. Assessment process cover different evaluation types in the virtual learning environment, linking the repositories with the correct assessment engine tools. The approach provides more accurate estimations of student's competencies level and a stronger relation between knowledge, activities, learning resources and type of evaluation tools, supporting in this way the automatic assessment and learning design generation. The process is supported by usage of educational standards and specifications and for an integral user modeling.

Keywords. Competencies, Adaptive Evaluation, Competence Assessment Process, Assessment Repositories, Virtual learning Environment

Introduction

The lifelong competence development is a global tendency and e-learning process is used with the purpose to eliminate the space and time barriers. In this context, new pedagogical models supported for new assessment process models are necessary.

In order to integrate properly assessment within learning process, some proposals claim as main ideas: 1) Introduce assessment as another key element of leaning process and 2) Link each learning objective or competence with one or many kind of assessments. In this way, assessment becomes a way of spiral measuring for student's learning achievement. Consequently, assessment turns into a good source for feedback to learners, for generation of recommendations and for drive adaptations in the learning environment.

In this context we have analysed some proposals of new competence assessment process models and software tools. In this paper, a characterization of these models and software tools is presented.

We propose two different approaches in order to improve competence e-assessment process. The first approach is the generation of adaptive assessment structure in the learning design based in the competence element definition. The second is to introduce the concept of new meta-information on the evaluation items in order to support information of competencies within the assessment repositories.

An *Adaptive Evaluation Engine Architecture* (AEEA) is proposed too to supports the improved competence e-assessment process completely.

Both approaches and the AEEA take into account different methods of assessment for monitor the student's competencies knowledge evolution and produce adaptive changes in assessment and learning design, and also it is our goal to integrate both approaches upon the open source learning management system dotLRN.

This paper is structured as follows: In section 1, the context and background of the proposal is described. In section 2, an extension for assessment process based on competencies evidence definition is proposed. In section 3, the data model for competencies assessment based on item's meta-data is exposed. In section 4, the assessment process model adopted and the AEEA proposal is presented. In section 5, we outline some concluding remarks and future work.

1. Context and Background

Competencies are complex processes that people put into play in order to solve problems and to carry out activities (both at everyday life and at the workplace) [1]. Users and their characteristics are key elements in a competence-based learning process development, especially considering that the very evolution over time of those characteristics reflect the expected acquisition of users' competencies.

There are different standard and specifications to support competence definitions; some of them include elements about the competence development process and the associated actors. Table 1 describes three of the most important approaches.

Table 1. Competence Definition Models

NAME	DESCRIPTION
IMS Reusable Definition of Competency or Educational Objectives Author: IMS Learning Consortium	Minimalist, but extensible competence and educational objectives description. It considers basic elements such as competence title, description and also it offer the possibility of extend the competence information adding a general element <statement> in which can be added specific elements in the competence definition. The RDCEO Schema can be used in both academic and business contexts. It focus is to offer.
HR-XML Consortium Competence Definition Author: HR-XML Consortium	The objective of this project is the creation of an XML schema to provide trading partners standardized and practical means to exchange information about competencies within a variety of business contexts [2]. Additionally to the general information in the RDECO specification, this approach define explicitly two specifics elements in the competence definition, the evidence used to capture information to substantiate the existence, sufficiency, or level of a Competence and Weight element to capture of information on the relative importance of the Competency in different aspects.
Ontology-Based Competency Management: Infrastructures for the Knowledge Intensive Learning Organization. Author: University of Alcalá	Above approaches are focused only in the information about the competence definition. This approach was created to support competence management, for this reason take into account elements such as the actors in the business process and job situations in which competence should be demonstrated. It principal purpose is to offer a complete framework to support decisions in human management in the business context.

In some countries, the trend is build and evaluates higher education academic curriculums driving by competencies definition. For example, in Colombia the

National Education Ministry has been develop, through the Superior Education Foment Colombian Institute (ICFES), a quality standard measuring reference for higher education checking the degree of competencies development in students attending the final year of undergraduate. This standard is called ECAES (for his Spanish acronym, Exámenes de Calidad de Educación Superior en Colombia) [3]. In ECAES for each academic curriculum a series of competencies are defined within his specific knowledge context.

Interoperability, reusability, efficiency and abstract modeling have always been the main characteristics in e-learning design and e-assessment standards and specifications. In particular IMS Question and Test Interoperability (QTI) [4] is an open technical e-learning specification to support the interoperability of systems and reusability of assessment resources. With QTI assessment items and test can be expressed and interchanged. IMS Learning Design (LD) [5] is a specification for a meta-language which enables the modeling of learning processes, designed to express many different pedagogies. The activities to develop in a learning design can be expressed with LD.

The current need of evaluation for competencies in long life learning process have exhibited some shortcomings of these standards and specifications mentioned. IMS QTI is just a specification about question definitions and response processing, and has nothing to do with teaching and learning activities [6]. Conversely, LD is used to support teaching-learning processes, but cannot explicitly support assessment [6].

In order to support the measuring of competencies development within an e-assessment process new assessment types are required. Table 2 presents taxonomy of new assessment types.

Table 2. Taxonomy of new assessment types required in competence e-learning process

Assessment Name	Definition
Summative Assessment	After a period of work, the learner takes a test and then the teacher marks the test and assigns a score. The test aims to summarize learning up to that point.
Formative Assessment	Consider an assessment ‘formative’ when the feedback from learning activities is used to adapt the teaching to meet the learner's needs or to students take control of their own learning.
Portfolio Assessment	Portfolio assessment is that it emphasizes and evidences the learning process as an active demonstration of knowledge. It is used for evaluating learning processes and learning outcomes. It is used to encourage student involvement in their assessment, their interaction with other students, teachers, parents and the larger community.
Self Assessment	Assessment where students making judgments about their own work. Students critique their own work, and form judgments about its strengths and weaknesses.
Peer Assessment	Student assessment of other students' work, both formative and summative.
360 Degree Feedback	Is feedback that comes from all around the student. The name refers to the 360 degrees in a circle, with the student in the center of the circle. Feedback is provided by subordinates, peers, and teachers. It also includes a self assessment and, in some cases, feedback from external sources.
Specific Competencies Assessment	Specific competencies are directly related to a specific occupation and are focused on the "know" and "do”. The individual competencies are a particular type of specific competencies.
Transversal Competencies Assessment	These affect various fields and are transferable to a multitude of functions or training programs. They are focused on the “to be". Special types of transversal competencies are the collaborative competencies. They allow a group of individuals to carry out a job as the result of joint effort and cohesion towards achieving a common goal.

Some researches have been produced software tools to support new specific types of assessment in e-learning as [7] - [16] and so on. Table 3 shows a summary of some tools with support for new types of assessment in e-learning environments. Nevertheless his data models are not based on standards producing loss of interoperability and reusability.

Therefore, in order to support a competence e-assessment process preserving interoperability, reusability, efficiency and abstract modeling, new models to extend the current specifications are required. First approaches in this sense [17] [18] propose to realize extensions providing insight into gaps between these different specifications, a UML model is proposed to extend and to combine QTI and LD specifications. Then, other research clarify the technical mechanism to do it, for example, it is possible to combine QTI and LD specifying how an outcome variable of QTI can be coupled to an LD property and integrating assessment applications tools to LD as services [19] - [24].

The most recent proposal over the initial idea of extend the current specifications promotes to create a new layer over QTI an LD establishing a new specification although building high-level assessment process modeling meta-language [3] [25].

Other kind of proposal has arrived with the LAMS project [26] in which LD and QTI specifications are the basis, but a totally new specification is being built in order to support whole range of possibilities in e-assessment.

Table 4 shows a summary of most important new models for e-assessment process focused in use of specifications and performing of traditional and new types of assessment.

Table 3. E-assessment tools based in his own data models for new types of assessment

Tool Name	Type of assessment
Peers [7]	Peer Assessment
Peer Grader [8]	Peer Assessment
Net Peas [9]	Peer Assessment
eSPARK [10]	Peer Assessment
Espace [11]	Peer Assessment
Turnitin Peer Review [12]	Peer Assessment
SEUV [13]	ECAES [3]
TELOS [14]	Portfolio Assessment, Specific Competencies Assessment
Coala [15]	Specific Competencies Assessment in programming
Middleware to connect APIS QTI engine and Google Maps [16]	Specific Competencies Assessment in manage of maps

Table 4. New models for e-assessment process for extend QTI and LD

Model Name	Type of model	New types of assessments validated
OUNL/CITO Assessment Model [17] [18]	* UML Model	Peer Assessment.
TENCompetence Assesment Model [19] – [24]	* UML Model * Data-centric model using XML	360 Degree Feedback, Portfolio assessment and Peer Assessment
APS [3] [25]	High-level assessment-specific process modeling language adopting a domain-specific modeling approach * Aggregation model * Conceptual Structure model * Process structure model	Peer Assessment
LAMS Model [26]	* UML Model * Database Model * Data-centric model using XML	Peer Assessment, Summative assessment and Formative Assessment

Table 5. E-assessment tools based on new models for e-assessment

Tool Name	Type of assessment	E-assessment Process Meta-Model
360 degree editor/runtime [19] [21]	360 Degree Feedback	TENCompetence Assessment Model
Portfolio assessment tool [19] [21]	Portfolio Assessment	TENCompetence Assessment Model
LAMS [26]	Peer Assessment, Summative assessment and Formative Assessment.	LAMS Model

Table 5 shows a summary of new tools for e-assessment based on these new models. Tools have been developed only for TENCompetence Assessment Model and LAMS Model. For OUNL/CITO assessment model were not developed Tools perhaps because TENCompetence Assessment Model is a reduce version of it and the research is concentrated in this small version.

According with the analysis of the state of the art in the competence e-assessment process there are different open questions in this research area such as: How it can express all types of assessment task in a standard learning design? What types of assessment are more appropriate for the educational objectives of a learning experience? How can these types of assessments to be customized to a specific learning context and to the expected benefits of a particular learning experience? What are the strategies for monitoring, assessment and evaluation? What are the adaptive strategies to provide in e-assessment process?. In particular, we are interesting in the automatic generation of adaptive assessment structures in a learning design, the support of whole e-assessment process and support of all kind of assessment types.

We propose two different ways to address the problem, the first use the *Competence Element Definition*, specifically, the evidence definition to decide how assessment structure can be generated. Our second approach describes a *Data Model for Competencies Assessment based on item's Meta-data* which are the input to an adaptive retrieval process. Finally the AEEA proposal incorporates the two approach mentioned above in a competence e-assessment process.

2. Assessment Process Based on Competencies Evidence Definition

Our interest in this first approach was define a particular model for competence definition that permit us to specify the necessary elements in order to generate adaptive learning designs in the context of learning management systems [27].

IMS-RDCEO was the specification selected because it offers the possibility to define completely, the necessary elements for the learning design generation, which were identified by analyzing different curricular design methodologies.

Competence definition consists of elements such as learning results, essential knowledge, evidences, and competence context. Each of them has a specific identifier in the definition.

The proposal to extend [27] is to make that each learning resource have a competence element associated, in particular, those which their type is assessment, have a reference to the identifier of the evidence element in the competence definition. This association support the assessment structure generation in the leaning design.

Figure 1 shows an example of a learning design generated, performance evidence activities are the assessment structures generated.

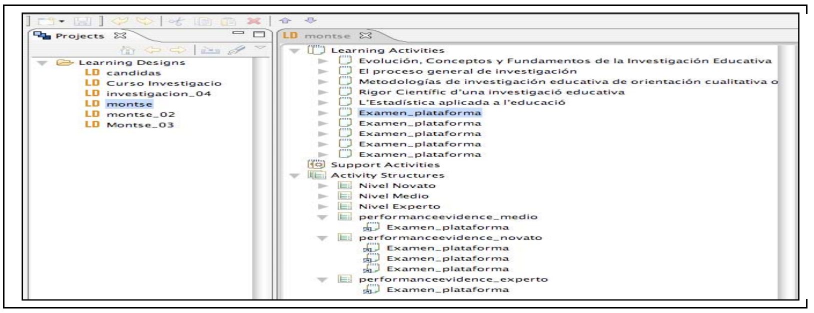

Figure 1. Learning Design with Assessment Structure

This first approach is based on the existence of repositories of different types of evidence and in the association of this evidence to the competence definition.

3. Data Model for Competencies Assessment based on Item's Meta-data

In this second approach we begin proposing a modification on dotLRN Assessment Package. This Package is an implementation of QTI Light Specification.

Assessment offers to users the possibilities to add general information about the items such as the item description, if the item is required or not, the feedback for the student, associated points and the description of question type.

Our interest is to improve the assessment package in order to support retrieval process based in the item meta-data.

In this way, we propose to associate information about the competence definition in the item meta-data. In the Table 6, the information proposed to add is described.

With this extra information and the data existing now we are testing some vectorial algorithms to support assessment construction step.

Table 6. Competence Definitions Models

Element of Information	Description	Objective
Competencies knowledge	Describes the main needed content to be addressed in order to be included in the adapted learning design for supporting competence acquisition.	Implement retrieval process based in the knowledge domain.
Competence Context	Environment in which the competence should be demonstrated.	Implement retrieval process based in the business associated context.

4. Adaptive Evaluation Engine Architecture (AEEA)

The proposal of adaptive assessment process is based on e-assessment process model proposed on [17] and [29] which define six steps. We group the steps in two big stages: *Design time* and *Run time*. Design time involves the first three process steps and Run time involves the last three process steps. We also propose that the adaptive decision could affect not only the feedback of the first step but also the feedback of the fourth step. Figure 2 show the e-assessment process model adopted.

Design Time Process Steps:

1. *Competencies Assessment Plan Design*: To select the sequence of assessment types that are appropriate for yield student's competencies. Construction and definition of decision rules and assessment policies for adaptation.
2. *Items Construction*: To prepare items of evaluation in different assessment authoring software tools.
3. *Tests Construction*: To build units of assessment for each type of assessment propose in the assessment plan. The unit must assure the type and value of expected response in the plan.

Run Time Steps:

4. *Assessment Execution*: To display tests according to assessment plan and manage the student's answers.
5. *Qualification, Classification and Response*: To calculate rubric score for tests and calculate the indicator score of competence assessment for each student.
6. *Adaptive Decision Making*: To follow the assessment plan rules for adaptive changes for each student. In some cases adaptations impact the execution of next tests, in other cases implies actualizations of the assessment plan.

In our previous work [28] a first approach of AEEA was proposal. In accord of the new e-assessment process model adopted, a second version has been produced. The AEEA is composed of two packages: *Author Assessment Package* and *Monitoring Assessment Package*. Figure 3 shows the new AEEA proposal.

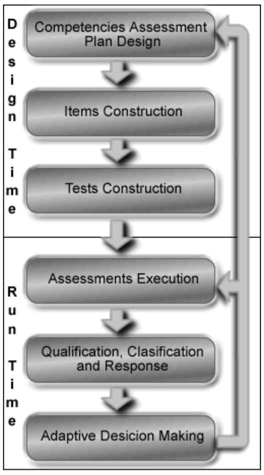

Figure 2. E-assessment process model adopted. Based on [15] and [17]

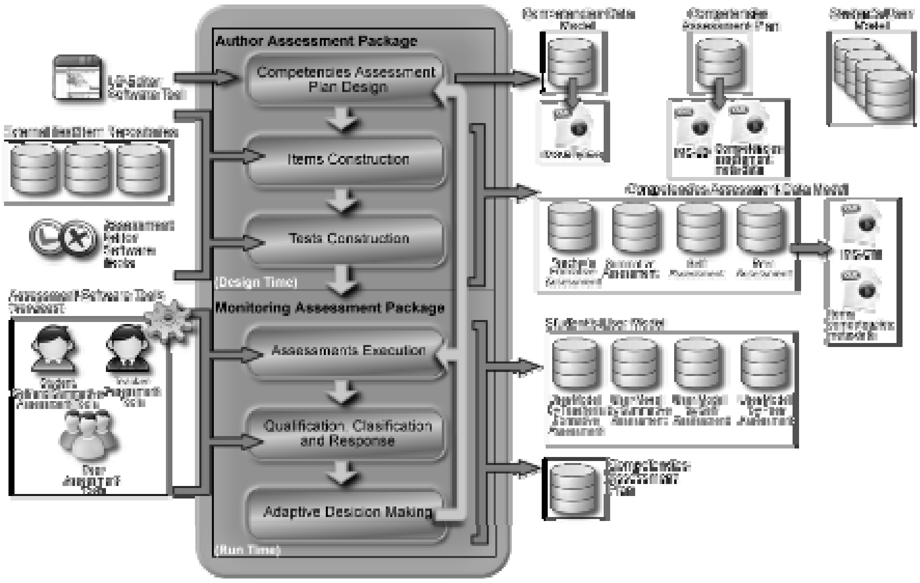

Figure 3. Adaptive Evaluation Engine Architecture

The *Author Assessment Package* supports the three first steps of e-assessment process in design time. The *Monitoring Assessment Package* supports the three last steps of e-assessment process in run time.

In the first step, *Competencies Assessment Plan Design*, an *LD Editor Software Tool* is used for configure the LD assessment plan where outcome variables of QTI can be coupled to LD properties. The result is the *Competencies Assessment Plan* supported over LD specification and XML meta-data for competencies information. Additionally, the *Competencies Data Model* and the *Student's User Model* are design too inside this step.

In the second and third steps, *Items Construction* and *Tests Construction*, items and tests are designed using *Assessment Editor Software Tools* and communication with *External Test/Item Repositories*. The complete result is the *Competencies Assessment Data Model* which is composed by four elements: *Teacher's Formative Assessment Model*, *Summative Assessment Model*, *Self Assessment Model* and a *Peer Assessment Model*. This data model is based in specifications as QTI and XML meta-data to keep relation between competencies and assessment items.

The *Monitoring Assessment Package* provides *Assessment Software Tools* as services to LD for monitoring user's assessment tasks and update *Student's User Model*, executes adaptive transformations according the LD assessment plan and deliver recommendations. In order to produce adaptive transformations, *Competencies Assessment Plan* rules are checked and *Student's User Model* is modified.

The AEEA has been conceived to support new types of assessment, in particular: Summative Assessment, Self Assessment, Teacher's Formative Assessment and Peer Assessment. Also, the most important, assessment objectives are integrated with the other key elements of learning design through the *Competencies Assessment Plan* and the monitoring process for delivering feedback to learners in all assessment tasks.

5. Conclusions

Assessments play a significant role in the competence development process, and consequently there is a clear need for run interoperable and adaptive assessment test in the e-learning systems.

In this paper, we have looked at the problems associated with adaptive e-assessment systems. Through an analysis of QTI and LD, we found that a combination and extension of both and service-oriented approach can meet technical requirements for supporting new forms of e-assessment.

We have proposed two different approaches in order to support competence e-assessment process. First, the generation of adaptive assessment structure in the learning design based on the competence element definition. Second, the concept of new meta-data on the evaluation items for maintains information of competencies. The AEEA proposal is based on new models for e-assessment process which extend LD and QTI specifications. The AEEA proposed can give direction to the use of the LD and QTI specification to align teaching, learning and assessment. This educational model has been constructed to match the new approach of assessment, and can be used to describe new assessment types. Our approach has advantages in supporting interoperability, flexibility, and seamless integration with learning activities.

Our working now is focused on the first part of the AEEA implementation, in particular, develop of the Assessment Editor Software Tools and also prepare items of evaluation in different repositories and testing some vectorial algorithms.

As future work, the implementation of the Assessment Software Tools as services of dotLRN and proof of the architecture for design time and run time are projected.

Acknowledgments

Authors would like to thank to LASPAU Program, The Academic and Professional Programs for the Americas, (scholarship No. 20080847), to the Alban Program and the European Union Program of High Level Scholarships for Latin America (scholarship No. E06D103680CO). Also, thanks to Universidad del Valle, Colombia for its support and for the Spanish Science and Education Ministry for the financial support of A2UN@ project (TIN2008-06862-C04-02/TSI).

References

[1] S. Tobón. Formación basada en competencias, ECOE Ediciones, Colombia, 2005

[2] C. Allen, Competencies 1.1 (measurable characteristics). HR-XML Recommendation. 2003.

[3] Antecedentes y Marco Legal ECAES, retrieved February 2009, http://200.26.128.174/web/index.php?option=com_docman&task=doc_view&gid=693&Itemid=59

[4] IMS QTI, retrieved April 2009, http://www.imsglobal.org/question/

[5] IMS LD, retrieved April 2009, http://www.imsglobal.org/learningdesign/

[6] Y. Miao, P. B. Sloep, R. Koper, Modeling Units of Assessment for Sharing Assessment Process Information: towards an Assessment Process Specification, Advances in Web Based Learning - Proceedings of the 7th International Conference on Web-based Learning (ICWL 2008)). Jinhua, China, 2008, 132-144

[7] A.H.H. Ngu, J. Shepherdm, Engineering the 'Peers' system: the development of a computer-assisted approach to peer assessment. *Research and Development in Higher Education* **18** (1995), 582-587.

[8] E. F. Gehringer. Electronic peer review and peer Trading in computer-science courses. Proceedings of the 32nd SIGSE Technical Sympposium on Computer Science Education, Charlotte, North Carolina. (2001)

[9] Z. Liu, S. Lin, S. Yuan. (2001) Experiencing NetPeas: Another way of learning, Lecture notes in computer science, Vol. 2198, 584-588

[10] J. Lockyer, Multisource feedback in the assessment of physician competencies. Journal Contin Educ. Health Prof., 23(1): 4-12 (2003)

[11] M. D. Volder, M. Rutjens, A. Slootmaker, H. Kurvers, M. Bitter, R. Kappe, H. Roossink, J. Goeijen, H. Reitzema. Espace: A new web-tool for peer assessment with in-built feedback quality system, in Proceedings of ABR &TLC Conference, Hawaii, USA, 2007.

[12] Turnitin, retrieved April 2009, http://turnitin.com /static/peerreview.html0

[13] Bustos, J.J., Uribe F., "Aplicación Web para realizar exámenes tipo ECAES de las asignaturas y planes de pregrado de la Universidad del Valle". Work of degree, Universidad del Valle, Cali, Colombia, Jun. 2007.

[14] G. Paquette, "An Ontology and a Software Framework for Competency Modeling and Management." Educational Technology & Society (IFETS), 10 (2), 1-21, 2007

[15] F. Jurado, O. C. Santos, M. A. Redondo, J. G. Boticario, M. Ortega, Providing Dynamic Instructional Adaptation in Programming Learning, Lecture Notes in Artificial Intelligence 5271, pp. 329-336, 2008. Berling, Germany: Springer, 2008.

[16] Bouzo, J., Batlle, H., & Blat, J. (2007). *Enhancing IMS QTI assessment with web maps.* Paper presented at the International workshop on Current research on IMS Learning Design and Lifelong Competence Development Infrastructures: The 3rd TENCompetence workshop, Barcelona, Spain.

[17] H. Hermans, J. Burgers, I. Latour, D. Joosten-ten Brinke, B. Giesbers, J. Van Bruggen, R. Koper, Educational model for Assessment. Retrieved Feb 2009 from: http://dspace.ou.nl/handle/1820/559

[18] D. Joosten-ten Brinke, J. Van Bruggen, H. Hermans, J. Burgers, B. Giesbers, R. Koper, I. Latour,, Modeling Assessment for Re-use of Traditional and New Types of Assessment, *Computers in Human Behavior* **23** (2007), 2721-2741.

[19] M. Petrov, A. Aleksieva-Petrova, K. Stefanov, J. Schoonenboom, Y. Miao, TENCompetence Assessment Model and Related Tools for Non Traditional Methods of Assessment. In H. W. Sligte & R. Koper (Eds). Proceedings of the 4th TENCompetence Open Workshop. Empowering Learners for Lifelong Competence Development: pedagogical, organisational and technological issues. April, 10-11, 2008, Madrid, Spain: SCO-Kohnstamm Instituut, Amsterdam, The Netherlands. 2008. 91-96

[20] M. Petrov, A. Aleksieva-Petrova, K. Stefanov, J. Schoonenboom,, Y. Miao, Evaluation of TENCompetence proof of concept assessment tools. In H. W. Sligte & R. Koper (Eds.). Proceedings of the 4th TENCompetence Open Workshop. Empowering Learners for Lifelong Competence Development: pedagogical, organisational and technological issues. April, 10-11, 2008, Madrid, Spain: SCO-Kohnstamm Instituut, Amsterdam, The Netherlands, 2008, 97-101

[21] M. Petrov, A. Aleksieva-Petrova, Developing a Software Tools for Nontraditional Methods of Assessment, International Scientific Conference Computer Science, Vol. **2** (2008), 490-495

[22] Miao, Y., & Koper, R. *An Efficient and Flexible Technical Approach to Develop and Deliver Online Peer Assessment.* Paper presented at the CSCL. (2007)

[23] Y. Miao, C. Tattersall, J. Schoonenboom, K. Stefanov, A. Aleksieva-Petrova. *Using Open Technical e-Learning Standards and Service Orientation to Support New Forms of e-assessment.* Paper presented at the International Workshop on Service Oriented Approaches and Lifelong Competence Development Infrastructures: The 2nd TENCompetence workshop Manchester. UK. (2007)

[24] Y. Miao, H. Vogten, H. Martens, R. Koper, *The Complementary Roles of IMS LD and IMS QTI in Supporting Effective Web-based Formative Assessment.* Paper presented at the Computers and Advanced Technology in Education 2007, Beijin, China, (2007).

[25] Y. Miao, T. Sodhi,, F. Brouns, P. B. Sloep, R. Koper, *Bridging the Gap between Practitioners and E-learning Standards: A Domain-Specific Modeling Approach.* In P. Dillenbourg & M. Specht (Eds.), Times of Convergence. Technologies Across Learning Contexts - Proceedings of the Third European Conference on Technology Enhanced Learning, EC-TEL 2008. September, 16-19, 2008, Maastricht, The Netherlands, (2008), 284-289

[26] LAMS, retrieved April 2009, http://www.lamsinternational.com/

[27] S. Baldiris, O. C. Santos, R. Fabregat, J. G. Boticario, Definición de Competencias basada en IMS – RDCEO para apoyar Procesos de Aprendizaje Adaptativos, ACOFI 2008. XXVIII Reunión Nacional. Cartagena de Indias (Colombia). September 2008

[28] B. Florián, S. M. Baldiris, R. Fabregat, Adaptive Integral Assessment Package for the A2UN@ Project, Proceedings of EAEEIE 2009, June 22-24, 2009, Valencia, Spain.

Evaluating accessible adaptable e-learning

Christopher DOUCE and Wendy PORCH
Institute of Educational Technology, Open University, UK

Abstract. Two different approaches can increase the accessibility of digital educational materials: content that has been built with the widest possible set of users in mind (universal design), or content that has been designed in such a way that it can be personalised to individual user needs and preferences (personalised design). This paper outlines a number of approaches that could be used to evaluate the provision of learning materials that have been adapted to or chosen for individual learners. A number of different perspectives are considered in this paper: a learner's perspective, the perspective of the tutor or teacher, and an institutional perspective. A number of complementary methodologies are presented. It is argued that the evaluation of a system that provides personalised learning content is a challenging activity that necessitates the application of multiple methods to effectively understand the underlying costs and benefits of providing personalised learning materials.

Keywords. accessibility, elearning, evaluation

Introduction

The emergence of tools such as virtual learning environments has enabled institutions to create digital services that can be used to augment face-to-face teaching. Learners can increasingly access a wealth of digital learning resources that can either help students become familiar with the subjects that are going to be discussed before a lecture or class, or allow learners to consolidate concepts that were taught during a lecture.

The development of these new technologies can, to a varying degree, be considered to be especially beneficial to learners with disabilities. Those students who are unable to attend a class may be able to use a virtual learning environment to make a contribution by participating within on-line activities. The accessibility of learning technologies ultimately depends upon the accessibility of the tools that are used to present learning materials (such as a VLE) as well as the learning material it contains.

Digital learning materials (or content) can be presented in a multitude of different formats. Digital content can be in the form of simple web pages, audio pod casts, fragments of video, or even interactive demonstrations such as simulations. The choice of what format to use may depend upon a wide range of factors, including the learning objectives that the educator aims to convey the availability of appropriate digital resources from a third party, the amount of time that an educator or learning technologist could spend creating those resources, and levels of internal expertise.

Although a range of digital resources can be created and presented through a virtual learning environment, there is a risk that some of the content may be inaccessible for certain groups. A visually impaired user may not be able to benefit from the provision of a video resource if it does not contain additional audio descriptions or other complementary materials. Similarly, a learner who has an auditory impairment may not be able to take advantage of a pod cast if the pod cast does not have an accompanying transcript.

The accessibility of learning material for learners who have disabilities rests upon representatives from an educational institution making practical decisions to ensure that no students are disadvantaged in terms of either being able to ‘access’ the materials through a preferred modality, or being disadvantaged through the adoption or use of learning objectives that makes their academic achievement difficult or even impossible.

The next section of this paper introduces the notion of content personalisation and adaptation as a way to enhance the accessibility of digital learning resources. This is contrasted with the competing notion of universal design: the ideal that all products, resources or systems should be accessible and usable by all people.

Within an educational institution, many different people have a collective responsibility regarding the provision of accessible learning. A number of groups or people who are acknowledged to have a responsibility are highlighted in the stakeholders section.

The focus of this paper lies with understanding how to evaluate whether it may be possible to deploy or develop a successful content personalisation approach to deliver the best possible educational experience for the widest possible group of learners. The EU4ALL project aims to build a practical framework to demonstrate the operation and potential benefits of content personalisation and other processes that can enhance the provision of accessibility [1]. A number of possible evaluation methods are presented within the methodologies section. This is then complemented with a discussion. The paper then concludes with a set of practical suggestions about how the EU4ALL framework and its content personalisation functionality can be evaluated.

1. Content personalisation and adaptation

There are two fundamental approaches for the development of accessible resources. The first is the development of a resource that is universal, i.e. a digital resource that all learners can use, regardless of their disability or sensory impairment. A video may be designed in such a way so that all the themes and principles it presents can be explained through the audio track with any accompanying visual descriptions merely emphasising the points that are being made. For the video to be accessible for people with hearing impairments, a set of subtitles may simultaneously be presented. This means, that the learning resource could be useful to people who have either visual or auditory impairments. In this way, such a video may be considered a product of universal design.

One argument against universal design is that learning resources that can be used by all people may not be optimal for everyone: each learner may have their own precise learning needs and requirements since each learner may have a unique combination of skills and disabilities. An alternative to the ideal of a universal resource is the notion of personalised or adaptable resources. A digital resource could be designed in such a way so it could be adapted (or customised) to match the needs and preferences of individuals. Some learners may prefer to listen to spoken versions of learning content due to a learning style preference. Some learners, on the other hand, may require subtitles of a particular size, colour, font or speed. Other learners may find that a transcript of a video might be more useful, since it can be more readily edited or manipulated.

The EU4ALL and TILE [2] projects have both attempted to explore the practicalities and challenges inherent with the creation of a system that enables educational materials and user interfaces to be adapted to the needs of individual users. The TILE project, an abbreviation for The Inclusive Learning Exchange, aimed to implement and explore an emerging generation of learning technology standards. Using a simple user interface that is akin to a 'wizard' end users (or learners) can specify a range of different content preference settings that suited their personal needs. Users can specify what media types are preferred, whether video resources are to contain subtitles or additional audio descriptions, for example. The TILE system would then choose and deliver resources that were suited to the preferences associated to a particular learner.

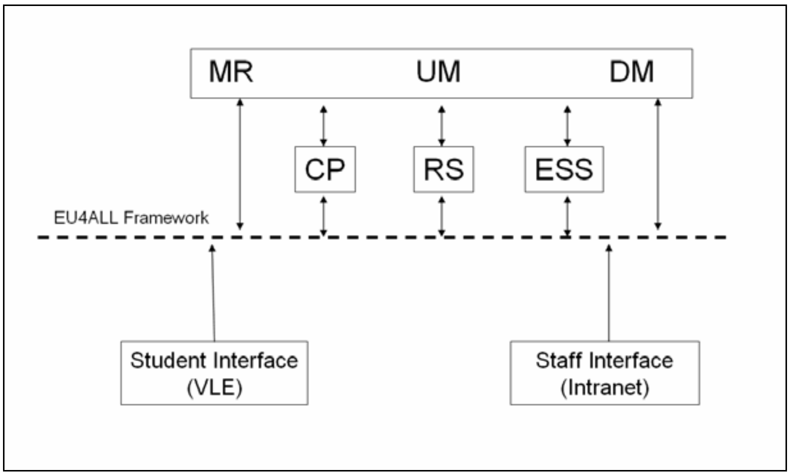

Figure 1. EU4ALL Framework conceptual diagram.

EU4ALL project has created a framework that can facilitate discussion about how the accessibility of virtual learning environments and e-learning systems in general might be improved, developed and enhanced. The EU4ALL framework can also be practically implemented through its proposed adoption of a service-oriented design and use of a new generation of learning technology standards. As a result, the framework has the potential to be used by a range of different VLE systems that can eventually deliver personalised e-learning to different users.

The EU4ALL framework comprises of a number of distinct components. The VLE system is used to store digital learning resources. Information about the accessibility of the resources is held within a component known as the Metadata Repository (MR). The accessibility information is represented in terms of whether a particular resource is appropriate for a particular modality. Information about the user is held within the User Model (UM). The choice of the content that is appropriate to the user is performed by the content personalisation module (CP). The EU4ALL framework offers other components that are discussed elsewhere, a Device Model (DM), a Recommending System (RS) and an E-Services Server (ESS) which provides accessibility provision administrative support in the form of workflow services.

It should be stated that there are some parallels that can be drawn between EU4ALL and the ADAPT[2] architecture [3]. Similarities can be seen in the application of a user modeling component and the fact that a structured ontology has been used to attempt to describe the different services that the ESS component could represent. Key differences relate to the application and combination of different learning technology standards and a clear and distinct focus towards the important issue of accessibility.

The learner interface to the system is facilitated through the link to the Virtual Learning Environment (VLE). Other external information systems can be connected to the EU4ALL framework, hence the link to an external 'Staff Intranet', where administrative personnel can gain access to other components, such as performance statistics that are produced by the ESS.

Different components of the EU4ALL framework have been implemented by different project partners. The User Modeling (UM) and Recommending System (RS) has been implemented by the aDeNu (Adaptive Dynamic online Educational system based oN User modeling) research group which are situated at the Universidad Nacional de Educación a Distancia (UNED) of Spain. The metadata repository has been developed by a commercial partner, ATOS Origin, and the content personalisation component has been implemented by an organisation called Indra. A substantial challenge lies with ensuring not only that all the individual components work together, but also to ensure that the end result from the entire system is of benefit to learners and different institutional stakeholders.

2. Stakeholders

The use, availability and presentation of accessible digital resources requires co-operation between different stakeholders. Whilst a single teacher or educator may be able to upload their own notes or presentations to a VLE which may be accessible in their own right, the availability and accessibility of the VLE is dependent upon a number of other people. The following table describes a number of important stakeholders who guide the development and provision of accessible e-learning. The names of the stakeholders are designed to be 'high level' groupings that can be used to guide discussion about the various roles and responsibilities. The notion of an academic manager, for example, can be represented by either a dean (a head of a faculty), or a head of a department.

Table 1. List of stakeholders that need to be considered as a part of the evaluation activities

Stakeholder	Roles and responsibilities
Learner	Requires access to accessible digital resources.
Tutor	Provides learner support and guidance. Responsibility varies depending upon institution. Potentially responsible for the uploading and selecting of materials.
Lecturer	Designs learning materials that are to be delivered to learners. Can be the same person as the tutor.
Learning Technologist	Provides tutor, lecturer and other technical staff guidance about how to best make use of different formats and learning technologies. Can have training responsibilities to ensure that staff are familiar with the operation of new technologies.

System Developer	A software specialist who is responsible for developing and enhancing the operation of one or more learning technologies. The developer needs to have an awareness of the importance of accessibility and is likely to liaise with the learning technologist and system administrator.
System Administrator	Responsible for deploying and ensuring continual operation of learning technologies that have been selected by the learning technologist and/or lecturing staff. Liaises with other technology personnel to ensure continual network operation and service. Also provides security support and backup services.
Disabilities Advisor	Offers institutional guidance to individual learners. In some institutions this stakeholder may be split amongst a number of roles, including needs assessments and sourcing of appropriate assistive technologies that are to be supplied to tutors.
Academic Manager	Line manager for individual lecturers or tutors. In terms of lecturers, the academic manager may be a head of a department or a dean, for example. For tutors (within the Open University), the line manager would be called a staff tutor. The academic manager may need to be aware of support issues and be able to make available resources to facilitate the provision of accessible learning.
Principle	Individual or group that is responsible for the operation of an institution. Principle has responsibilities for adhering to national and international legislation and developing organisational structures that permit the delivery of accessible learning.

This table is by no means complete and its precise constituents will vary depending upon the differences between institutions. All of these stakeholders have a role to play regarding the delivery of accessible learning experience.

Given a similar list of stakeholders, a substantial question that should be asked is: will these stakeholders accept the development or the delivery of a system that presents learning materials that are personalised to the needs of individual learners? The following section aims to consider what evaluation methodologies could be used to uncover what issues or barriers may prevent the acceptance or development of the a personalised approach to accessibility.

3. Evaluation Methodologies

To understand the complexity of introducing a system that personalises learning material requires the application of a number of different evaluation methods. The choice of the method depends upon the question that is to be assessed, and this varies between the perspectives held by each of the stakeholders. A learner will hold a different perspective than the tutor, or the principle, for example.

This section presents a brief description of the different methods that could be used to evaluate the EU4ALL framework (outlined in figure 1) and its content personalisation functionality.

3.1. Software Inspections

A software inspection, also known as a code review, is where the internals of a software system are shared between a number of different developers who then debate its internal design and quality, drawing upon prior experience of other systems. Issues discovered as a result of applying this method are likely to be discussed and any design flaws may be either addressed or recorded for further consideration. It is possible that this approach could be modified to facilitate the inspection or internal evaluation of an accessible adaptable resource.

3.2. Automated Checking

Automated checking tools can be used to provide guidance about whether digital resources conform to a number of well known accessibility guidance. Tools, such as the Imergo web compliance manager [4] can be used to provide resource designers and development an indication as to whether they have missed any important issues and indicate, in some cases, whether assessment is necessary to complete checking. The W3C Web Content Accessibility Guidelines [5], however, are oriented towards the principle of universal accessibility. When interpreting the results from automated checkers, the needs and preferences of the individual to which a particular resource may relate to should be taken into account.

3.3. Heuristic Evaluations

A heuristic evaluation is a recognised human-computer interaction technique that aims to quickly identify usability problems with an interactive device by asking usability experts to assess an interface using a number of known usability principles [6, 7]. A heuristic evaluation is likely to be useful to evaluate the interface that a student uses to gain access to the learning material that is then personalised. The approach can also be used to evaluate the interfaces that tutors, lecturers or administrators use to add or change learning materials that are presented to end users.

3.4. Predictive Evaluations

Predictive evaluations represent a range of techniques that are designed to predict the performance or the effect of a design change. A well known predictive technique is called GOMS [7, 8]. The amount of time a user may spend on a particular screen or page is estimated in terms of time allocated to the analysis of elements that can be found on a screen. The length of time attributed to the execution of actions (such as menu choices or mouse clicks) can also be estimated. The resulting data can be used to provide clear information about the effectiveness of one design over another.

3.5. End-user Evaluations

A difficulty with predictive evaluation is that they do not take into account differences between users. A difficulty of heuristic evaluations is that experts may fail to find all usability problems, or alternatively find usability problems that do not exist (known as a false positive). Evaluating a system with real users allows researchers to gain an in-depth understanding of real difficulties that are faced, given a particular task or activity. End-user evaluations are often carried out after a series of heuristic evaluations have been completed since they are considered to be both expensive and time consuming. This said, end user evaluations are considered essential to uncover accessibility problems.

3.6. Field Evaluations

Whilst end-user evaluations are usually carried out within a laboratory, field evaluations are carried out in the situation where a product or system is likely to be used [7]. If a virtual learning environment is to be primarily used at home, a field evaluation will take account of whether the system is appropriate for the environment in which the system inhabits. Field evaluations have the potential to illustrate the impact of issues such as personal assistive technology and operating system preferences on the usability and accessibility of a system. Field evaluations may involve an observer, or may involve end users making diary entries at either critical events or certain points throughout the day to record observations and current activity. Field evaluations are also useful to understand how tutors and lecturers may create their own learning material, and whether a system needs to change or offer alternative functionality to help the user with their tasks.

3.7. Pedagogic Evaluations

Pedagogic evaluations aim to assess whether a system (or a pedagogic practice) can facilitate learning. Assessment of learning is usually carried out through a test or task that has been designed to explore whether certain principles or knowledge has been retained. The effectiveness or performance of a learning tool, system or practice may be demonstrated by offering pre and post 'learning task' tests to participants. Control experiments can be used to explore the effect or power of a particular system. Whilst test scores can provide a quantitative assessment of learning, a complementary qualitative approach is to explore the attitudes or perceptions learners hold regarding a system. Learners could be asked if they felt that one system was better than another in terms of usability or accessibility. More detailed questions, presented in terms of usability and user experience goals, [7] may be able to assess whether a system could either positively or negatively interfere with learning activities and tasks.

3.8. Economic Evaluations

A substantial evaluation consideration should be whether or not a new system is likely to be cost effective either in terms of how much time a system takes to operate, or how much money it could cost to implement and maintain. These financial dimensions can be implicitly seen within some of the other evaluation approaches. The predictive evaluation method aims to proportion time against elements of an interface. The act of conducting a user evaluation (with either the tutor or a learner) may indicate clearly that certain tasks may be difficult to understand. In yielding such a response, it may be possible to conclude that a system may be costly to use, and increase the risk of it not being used or accepted. A thorough economic evaluation in terms of whether any new system can be connected to an existing information technology infrastructure is also necessary. If, from a maintenance perspective, rework or redevelopment of existing systems is necessary or the purchasing (and operating) of additional hardware, the management personnel within an organisation need a clear picture about its underlying costs and benefits.

3.9. Perception Evaluation

It is important to take into account the attitudes that the various stakeholders may hold towards the proposed system since this is likely to influence whether it is likely to be accepted, regardless of whether or not the system is likely to improve the learner experience. Perception evaluation, as it is called here, can be carried out by carrying out a series of stakeholder interviews. If the new system requires the mobilization of additional resources to ensure that the system can be effectively deployed, this technique will help the attitudes relating to such issues to be explored. It may be possible to mitigate against challenging attitudes by presentation of end user experiences, current legislation and potential benefits to the institution as well as to end users.

4. Discussion

The comprehensive evaluation of a new system (or framework) like EU4ALL that aims to deliver learning materials and services that are customised to an individual's needs and preferences is a considerably challenging task. Not only are there a number of different methods and approaches that could be used, there are also a wide and varied number of stakeholders whose views must all be taken into consideration.

The end users perspective is essential when it comes to understanding the difficulties that learners face when interacting with a system. The difficulty of using a system is likely to go hand in hand with the task that a system is used for. Whilst consuming content that has been personalised for a learner may be an activity that could be straightforward, there are significant challenges in understanding how lecturers and tutors might be encouraged to create materials that can be 'personalised' when the task of a lecturer is not to create personalised content, but to lecture or to teach. As a result, any system that allows personalised content to be authored must be as easy to use as possible. One of the challenges of evaluation is to find an approach that enables some of the key difficulties to be identified. When issues are identified, their usability or accessibility could be further developed, or tasks could be reduced in complexity.

Another key issue that must be remembered when conducting an evaluation of any system is the issue of ethics. This issue is particularly significant when we begin to consider the issue of pedagogic evaluations. Consider the example of constructing an experiment where there are two systems: one system that provides learning materials that are universally accessible, another system that may be personalised to an individual's needs and preferences. If both systems were deployed in a formal educational setting, it may be possible to argue that one student may have an advantage over the other if the system that is the subject of the evaluation is considered to be ultimately successful. The key, of course, is to always ensure that the participant is always considered to be the most important element of an evaluation. The technology that may be the ultimate focus of a series of studies should always be of secondary importance. It should be unambiguously stated that any evaluation should not be connected with a formal course or qualification. Should a pedagogic evaluation be considered to be required, it may be necessary to create a set of learning materials that are representative of those that may be found within a real course. One of the challenges is to create materials that are interesting enough to persuade participants to become involved with the evaluation.

A further challenge inherent when performing the evaluation of any recommendation or content personalisation system is to assess how the system may be deployed or used within an existing system. To build a complete picture and to learn what must be done in order for real institutions to adopt the proposed approach, consultation with administrative and managerial stakeholders will be necessary. Since the structures of organisations differ, it is suggested that stakeholders from a number of different institutions are consulted. One approach to efficiently gather information relating to the subject of deployment is to carry out a series of focus groups or workshops to assess the political, economic, social and technological (PEST) barriers for acceptance.

The process of evaluation is likely to point towards the ways in which the framework may be applied within a large organisations, such as the Open University. From one perspective, EU4ALL can be seen as technical framework that can guide the practical implementation of new learning technologies and enhancements to existing VLE systems. From a different perspective, it can be used as a tool to uncover the way that information technology can enhance the provision of services to people with disabilities.

5. Conclusion

To summarise, a multi-method approach is necessary to comprehensively evaluate the acceptance of a new accessibility framework that contains a content personalisation component. It is necessary to evaluate the perspectives of both the learner and those who are responsible for creating new adaptable (or customisable) digital resources. It is also necessary to assess the extent to which a system may be integrated with and connected to an existing infrastructure. A number of different evaluation approaches can be drawn upon. The following practical activities are suggested:

1. Conducting heuristic evaluations of initial interfaces to assess the efficiency of proposed interfaces.
2. Complement heuristic evaluations with automated testing of digital resources, taking account of end user profiles.
3. Complement heuristic evaluations with a series of usability tests.
4. Design a series of qualitative pedagogic evaluations and liaise with internal pedagogic evaluation experts to assess the effectiveness of their design.
5. Carry out a series of workshops for senior stakeholders that aim to uncover the complexities inherent in supporting the delivery of accessible material and services.

By conducting a combination of these approaches, it is hoped that a rich understanding of the complexities inherent in developing and deploying a framework that contains a content personalisation system will emerge. The resulting lessons can then be used to offer feedback into further designs and be used to inform how most effectively offer mechanisms that can support the provision of accessibility services to further and higher education institutions through the application of information technology.

References

[1] Douce, C. R., Porch, W., Cooper, M. & Heath, A. European Unified Framework for Accessible Lifelong Learning. Fourteenth International Conference for the Association of Learning Technology Conference (ALT-C), Nottingham University, Nottingham, UK, (2007)

[2] Treviranus, J. and Brewer, J. Developing and Reusing Accessible Content and Applications, in Reusing Online Resources: A Sustainable Approach to eLearning, (Ed.) Allison Littlejohn. Kogan Page, London, 2003.

[3] Brusilovsky, P., Sosnovsky, S., and Yudelson, M. Ontology-based framework for user model interoperability in distributed learning environments. In: G. Richards (ed.) Proceedings of World Conference on E-Learning, E-Learn 2005, Vancouver, Canada, October 24-28, 2005, AACE, 2851-2855.

[4] Chisholm, W., Vanderheiden, G., and Jacobs, I. 1999. Web content accessibility guidelines 1.0. http://www.w3.org/TR/WCAG10, accessed 8 April 2009

[5] Imergo accessibility checker, http://www.imergo.com/, accessed 8 April 2009

[6] Nielsen, J., and Molich, R. Heuristic evaluation of user interfaces, Proc. ACM CHI'90 Conf. (Seattle, WA, 1-5 April), (1990), 249-256.

[7] Preece, J., Rogers, Y. and Sharp, H. Interaction design: beyond human-computer interaction, John Wiley & Sons, 2002.

[8] Card, Moran, Newell. The Keystroke-Level Model for User Performance Time with Interactive Systems, Communications of the ACM, 23, (1980), 396-410.