Adapting e-learning and learning services for people with disabilities

Conference or Workshop Item

ADAPTING E-LEARNING AND LEARNING SERVICES FOR PEOPLE WITH DISABILITIES

Christopher Douce*, Wendy Porch, Martyn Cooper
Institute of Educational Technology, Open University, Milton Keynes, MK7 6AA, United Kingdom
c.douce@open.ac.uk

ABSTRACT
Providing learning materials and support services that are adapted to the needs of individuals has the potential to enable learners to obtain maximal benefit from university level studies. This paper describes EU4ALL project which has been exploring how to present customized learning materials and services for people with disabilities. A number of the technical components of the EU4ALL framework are described. This is followed with a brief description of prototype implementations. This is then followed by a discussion of a number of research directions that may enhance the adaptability, usability and accessibility of information and support systems can be used and consumed by a diverse user population.

KEYWORDS Accessibility, e-learning, content personalization, frameworks.

INTRODUCTION

The EU4ALL framework is a conceptual and practical tool that can be used to guide the development of adaptable learning technology systems and processes to offer support for students with disabilities. The paper begins by presenting two different scenarios. The first scenario is used to illustrate the difficulties that students with disabilities may face when they enter higher education. The second scenario illustrates how learning can be supported through systems and technology that supports personalization and adaptation. This overview is then complemented by an in-depth discussion of one of the most important driving forces that has guided research in this area: legislation.

The EU4ALL framework has emerged from a four year project that has developed a standards-based architecture. To inform the creation of the framework the project has carried out both (1) a comprehensive analysis of literature that provides guidance surrounding the development of learning technology systems, and (2) interviewed a large number of stakeholders, including lecturers, learning technologists and student support managers to assess the range of different support mechanisms are available for disabled learners who are embarking upon a period of university study.

The two main areas the framework aims to address include:

1. Enhancing the learning experience by presenting learning materials that are appropriate for and matched to modality and end-user devices preferences, such as mobile devices or assistive technologies used with a desktop computer.
2. Providing a wide range of services that an institution can adopt to ensure that the needs of learners who have disabilities are most appropriately supported.

The most important components of the architecture, such as the user modelling and content personalization elements are described within the EU4ALL framework section. A complementary section, entitled Adaptable E-Services, describes an approach to developing and conceptualizing and information system that supports the needs of disabled learners. This is then followed by a brief presentation of how the framework has been implemented through two pilot sites.

The paper concludes by presenting a number of areas of research that could guide the development of flexible and interoperable services that can be adapted and customized to the needs of end users.

LEARNING SCENARIO

This section presents two different scenarios: one where adaptations are considered as an afterthought, another where adaptations are made to make a learner to study.

Scenario 1

David, a student with a visual impairment is enrolled at a university. During his first week he attends a class where he discovers that a lot of material is being presented through a series of PowerPoint presentations. During a lecture, David realizes that there is not sufficient information provided by the lecturer to fully understand the concepts that are being introduced. Concerned by this, David speaks to his lecturer who then says that he will place them on the University Virtual Learning Environment (VLE). At home, David tries to access this material but finds it difficult because he finds it difficult to navigate through the VLE system, and he is also using an version of an assistive technology product which no longer suits his needs.

Scenario 2

David has enrolled on a university course. Before he starts the course a Disability Student Service advisor contacts him and asks whether he has had a recent assessment to determine whether his assistive technology currently meets his needs. He says the last assessment he had was several years ago, so the advisor makes an appointment for him to speak with an assistive technology specialist. When he has his assessment, he discovers that a screen reader program is most suited to his needs. He is told about some training material that was contained on the software CD which he loads and uses. Before he goes to his first lecture, he decides to access the university virtual learning environment. When he accesses it for the first time he discovers that the digital materials that he finds are customized just for him and his screen reader. David does not have to waste time viewing materials that do not add to his learning. When he goes to the lecture, the lecturer does what he can to ensure that any graphics presented using PowerPoint to all the students are described as clearly as possible; it was obvious that the lecturer had heard that this was something that he (along with other students!) would benefit from.

Scenario Discussion

This scenario illustrates that education adaptation can occur in a number of different ways. To proceed with his learning, David has to overcome a number of difficult barriers: he has to have access to appropriate assistive technology, support to help him to use that assistive technology in the form of training, information about how to support his needs given to appropriate members of staff, and digital learning materials made available through a virtual learning environment. The VLE system will enable David and all students to access materials

that can be studied either before or after one or more lecturers. In essence, there are two forms of adaptations. The first is in terms of adaptations that are performed or carried out by an institution. The second is in terms of adaptations that are performed by digital tools with the intention of helping a learner to access learning materials that are most appropriate to their needs.

A VLE can store and present a wide range of different educational media such as audio podcasts, video snippets, multimedia animations, interactive simulations, PowerPoint presentations which can contain any number of graphics and PDF files. Not only may a learner with disabilities have difficulty working with and manipulating certain media types given the assistive technology they might use, but materials that are inaccessible for one user can negatively impact on the usability of a system especially if learners spend time determine whether a digital resource is going to be able to support their study. Selecting (or adapting) resources that are accessible for one particular user can increase the effectiveness of a digital learning environment.

In some circumstances, any user, regardless of disability may prefer one modality over another. A learner, for example, when travelling on a busy train may choose to mute the audio channel of his or her laptop to avoid distracting fellow passengers. This exposes the possibility that the designers of digital resources may have to take account of the fact that the functional and modality needs of users may change dynamically depending upon a users context or situation and that the accessibility of learning material need not only benefit learners with disabilities.

Although such adaptations are likely to be performed within the boundaries of a mobile device or system, it should be stated that the environmental adaptations, such as communication of teaching changes could be mediated through the judicious use of information technology systems.

LEARNING ENVIRONMENTS, DISABILITY AND ACCESSIBILITY

Before moving on to consider how an adaptable system for higher education may be designed or implemented it is useful to further consider the definition of the terms *disability, impairment* and *assistive technology*.

An *impairment* can be considered to be the attenuation or reduction of operation of a functional sense (such as hearing or sight) or ability (such as speech or movement). The presence of particular impairment may reduce a person's ability to participate within a range of tasks or activities. An assistive technology may alleviate the presence of an impairment. Whilst there are many generic definitions of disability and definitions of accessibility focusing on reducing barriers to accessing the Web, the IMS Global Learning Consortium offers a more education specific definition of both *disability* and *accessibility*:

> [..] the term disability has been re-defined as a mismatch between the needs of the learner and the education offered. It is therefore not a personal trait but an artefact of the relationship between the learner and the learning environment or education delivery. Accessibility, given this re-definition, is the ability of the learning environment to adjust to the needs of all learners. Accessibility is determined by the flexibility of the education environment (with respect to presentation, control methods, access modality, and learner supports) and the availability of adequate alternative-but-equivalent content and activities. The needs and preferences of a user may arise from the context or environment the user is in … Accessible systems adjust the user interface of the learning environment, locate needed resources and adjust the properties of the resources to match the needs and preferences of the user. [1]

The term *learning environment* is one that is broad. On one hand it can be used to refer to the physical environment of a user, such as a classroom. It may also be conceptualized as the immediate working environment which may comprise a personal computer and a range of assistive technologies. A *learning environment* could also be conceptualized as a 'software' environment such as a VLE.

In some respects, software environments have the potential to empower learners with disabilities. People who are unable to directly travel to university lecture theatres may be able to use technologies to make effective contributions to learning activities. People who are visually impaired may be able to make use of assistive technologies such as screen readers to gain access to and learn from materials that are provided on-line. Whilst new technologies can facilitate the creation of new learning and teaching opportunities, there is a possibility that these new technologies may potentially disenfranchise or alienate learners should they be inaccessible or designed in such a way that makes them either difficult or impossible to use with assistive technologies.

The notion of an accessible learning environment is not one that is limited to the digital realm. True accessible learning environments take account of the physical surroundings, the immediate working environment as well as the tools that learners have at their disposal. Within the United Kingdom, the Disability Discrimination Act 1995 (DDA), as modified by the Special Educational Needs and Disability Act 2005 (SENDA), educational institutions such as schools, colleges and universities are required to anticipate the needs of students with disabilities. In essence, organizations need to consider the diverse needs of disabled students in advance and considering the notion of reasonable adjustments to prevent the possibility of discrimination.

One way to ensure that the diverse needs of learners are considered is to develop and deploy a range of support services which become embedded within the culture of an organization. Embedding these services can be performed through staff induction or training programmes. Such programmes can introduce employees and support workers to existing (or new) information systems that help to facilitate the delivery of educational services to students.

THE EU4ALL FRAMEWORK

The EU4ALL Framework is a conceptual and practical framework that has been designed with the intention of facilitating the development and enhancement of adaptable accessibility services that can be delivered or supported through the use of digital technologies, facilitated through the application of learning technology standards. The EU4ALL framework sits alongside and compliments a number of other conceptual frameworks. Seale [2] suggests that different frameworks can be used to understand institutional, community and individual responses to accessibility.

In the concluding chapter of her book *E-learning and disability in higher education: accessibility research and practice*, Seale points towards the possibility that reference models (which can also be considered as frameworks) can be used to support the development of accessible e-learning. Seale hopes that such reference models ‘will facilitate a common understanding of the components of the domain and their interfaces as well as provide a map for service development’. Seale imagines a model that ‘describes the scope of the accessibility domain … giving an overview of current practices, processes and systems’, ‘offering a set of use cases that describe common solution patterns’, and ‘offer service

definitions for both existing services and those that need to be developed for the accessibility domain area'. These words can be interpreted as a challenge that necessitates a response.

A substantial amount of work has been carried out with the intention of understanding how to make digital learning resource, such as web pages accessible to people who use assistive technologies. One body of work that continues to be important includes the Web Content Accessibility Guidelines (WCAG) [3]. The WCAG guidelines do not, however, specifically consider the issue of accessibility of learning materials, which can be considered in two contrasting ways.

A digital resource can either be designed in such a way so it will be useful to the majority of learners in an approach generally known as universal design [2], or a resource can be customised or adapted to match the needs of individual learners. This approach can be called 'designing for adaptability' [2], or individualised design. With universal design, an instructional video may contain subtitles and a corresponding audio track. To ensure that people with visual disabilities can understand what is being presented through the video, the audio track must directly reflect what is being shown using the video. If this is not the case additional audio descriptions need to be included to ensure that all pedagogically relevant information in the video is conveyed. The resulting video can be viewed by people who have a range of auditory and visual impairments. Whilst such a resource may seem to be universally accessible, the issue becomes somewhat more challenging if we consider the requirements of individual learners. Some learners may find it difficult to read subtitles at the rate they are presented. Furthermore, for some learners, the presence of an additional audio narration track may prove to be unnecessarily distracting. Some learners may instead prefer to work with a transcript which they could manipulate or navigate with an assistive technology.

The adaptation or personalization of learning materials offers learners the opportunity to be presented with resources that are best suited to their personal needs and preferences. The notion of needs and preferences, whether it being in terms of preferred modality or content type, is an issue that has been discussed within international standards arenas. The IMS Accessibility Learner Information Profile (AccLIP) specification outlines a data structure that can be used to describe learner preferences [4]. The AccLIP structure can be used with a corresponding learning object and a learning material accessibility metadata specification called AccMD, meaning 'accessibility metadata' [5]. Versions of these standards have recent become international standards [6].

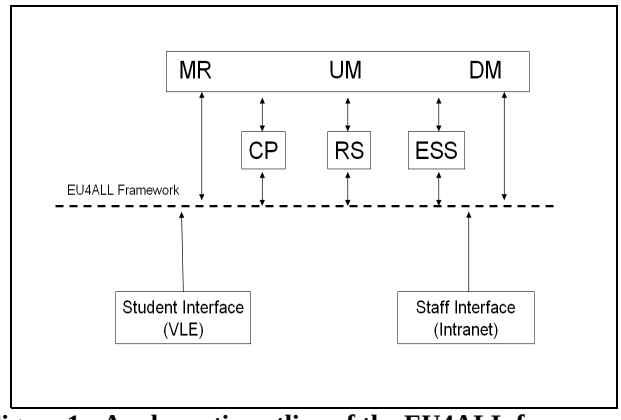

Figure 1 - A schematic outline of the EU4ALL framework

Figure 1 depicts a schematic illustration of the framework. A fundamental principle underpinning the framework is the notion of the learner. The key components of the system include a content delivery system, such as a virtual learning environment (VLE), a user

modelling service (UM), a content personalization system (CP), metadata repository system (MR), a recommender system (RS) and a device modelling system (DM). The e-services server (ESS), which will be described later, is an institution facing component that aims to provide ways to manage the deliver of accessibility services. This component can be used to guide the development of new digital resources that can be consumed by learners and can offer a framework for the development of accessibility support systems.

The EU4ALL framework presents a number of components that are necessary to make use of learning content personalization. These include the user modelling component where the end user personal needs data is stored, a mechanism called a metadata repository that describes how appropriate certain digital resources may be for users with particular functional (or modality) requirements, a content personalization component that performs the matching between the content and the user data, and the vehicle through which the content is delivered.

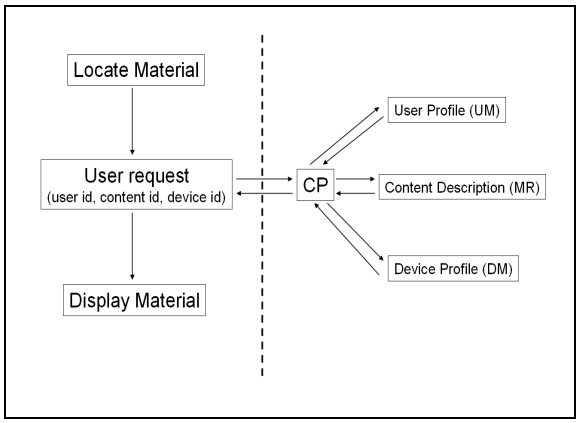

Figure 2 - Personalizing learning content

The operation of the content personalization (CP) is illustrated in Fig 2 which shows a simple use case of a learner wishing to gain access to some materials. Through a VLE/LMS, the learner navigates to a particular page or section. Upon receipt of a request to display some learning material, a request is sent to the CP unit, which then in turn interrogates the UM component, and finds the most appropriate version of the resource for that user, whilst also attempting to find a resource that is appropriate to the users' current delivery environment and device. The content delivery environment, in most cases, is likely to be a virtual learning environment that is presented through an internet browser running on a personal computer. There is no reason to prevent learners from accessing the material through different devices, such as mobile phones or netbooks which may have a limited screen size.

A final part of the framework which relates to the learner interface is the recommendation system [7]. Examples of recommender systems can easily be seen within e-commerce websites; if you purchase a product from an on-line retailer, the retailer will gradually build a model of what types of products you may be interested in. The notion of the recommender system is being adopted by learning technology systems. The EU4ALL recommender system, in principle, will present the learner with useful links and activities, such as current forum discussions, that relate to current learning activities such as lectures and assignments.

ADAPTABLE E-SERVICES

As suggested earlier, higher and further educational institutions are often obliged to provide people with disabilities effective and appropriate support. The provision of services is often managed or assisted by a central administrative unit, sometimes in collaboration with faculty and departmental units. The Open University, for example, has a central unit that carries out assistive technology assessments with assistance from a local government authority. The central unit also offers guidance to regional offices and also provides the loan of essential assistive technologies when they are not immediately available for students to enable different student groups to begin a course.

There are a large number of stakeholders that are involved with supporting disabled students. Seale [2] suggests that accessibility requires individual, community and institutional involvement. As a result, the interfaces between the different individuals, groups and units have the potential to become complex and having a complete understanding of a whole support 'system' may be difficult. If learner and student support is distributed throughout a number of different units, there is the risk that support may become disjointed or discontinuous.

An important part of the EU4ALL framework is a component named the E-Services Server (ESS). The ESS takes inspiration from two different sources: the requirement gathering activities that have studied the different activities that organizations carry out to support the needs of disabled learners, and contemporary ideas regarding workflow management and planning that have been drawn from the fields of information systems and computer science. The ESS component intends to provide institutional level support for the delivery of services that necessitate the involvement and co-operation of a number of different stakeholders.

The requirements gathering activities have established what can be described as a broad *ontology of services*. This ontology, [11] can be considered as a conceptual map or representation of ideal institutional processes which has the potential to inform the creation of new services with the intention of ultimately improving the educational experience for people with disabilities.

When attempting to consider the most effective approaches and processes that could be applied to support learners, an educational institution could use the notion of workflow and service management to pose the following questions:

(1) Are students receiving the quality of service that they are entitled to?

(2) Are they being provided with services within appropriate time scales?

(3) How much does on-going service provision cost to an institution?

(4) Are there processes in place to take account of situations where key members of support staff are unavailable?

One way to begin to answer these questions is to undertake a systematic analysis of existing service provision with a view to implementing information systems that could be able to support service provision. By implementing practical systems, with stakeholder consultation, it will be possible to collect metrics relating to the quality and responsiveness of support services. Information gathered from the ESS can be used by service managers to ensure that costs are effectively managed and all student groups are provided with equal opportunities. Furthermore, gathering data on the effectiveness of workflow may enable process bottlenecks to be highlighted. A proactive correction to service provision could ensure effective on-going provision of accessibility services.

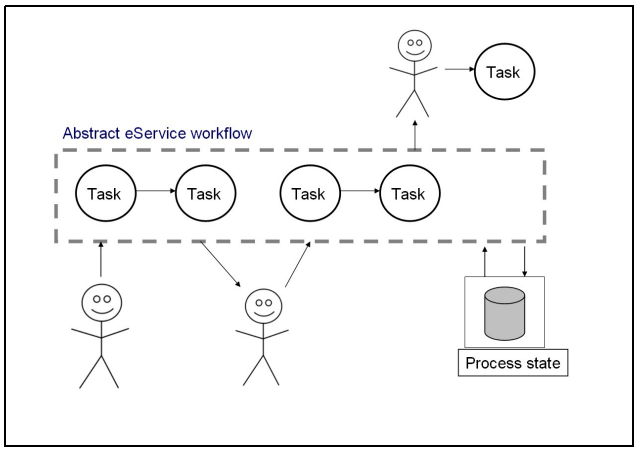

Figure 3 - E-Services Server (ESS) assisting with workflow

Fig 3 presents a high-level conceptual illustration of the E-Services server. The role of the ESS is to co-ordinate the delivery of accessibility services. Accessibility provision is dependent upon a number of different actors operating within different departments, as illustrated by the three characters. By way of an example, a wheelchair user may be required to attend a field trip. A member of the academic department may then be required to act upon this request to determine whether the chosen accommodation is accessible. Further checks may have to be carried out to ensure that the travel arrangements that are made to the field trip site are accessible. Finally, requests for additional assistive technology may internally to ensure that users can participate within the field trip.

IMPLEMENTATION

To further explore the framework the EU4ALL project has attempted to illustrate its operation with two different systems and sites: the Moodle VLE [8] used by the Open University in the UK, and the dotLRN VLE used by Universidad Nacional de Educación a Distancia (UNED), in Spain [9]. Different partners have undertaken the development of the various framework components. The content personalization unit (CP) has been developed by Indra, in Spain. The user modeling component which makes use of the AccLIP specification has been developed by UNED, and the metadata repository component which makes use of the AccMD specification has been developed by ATOS Origin, Spain. Interfaces between the two VLE systems and the framework components have been built by the respective universities, The Open University and UNED. The technical accessibility of each VLE is subject to continual improvement and development by drawing upon current guidelines such as WCAG 2.0

The implementation of the framework draws upon the principles of Service Oriented Architecture (SOA). An SOA based approach allows heterogeneous systems to be connected together and functionality of a software system to be distributed amongst a number of discrete components, each of which has a well defined interface.

To illustrate the operation of the framework, both universities created adaptable learning content and associated accessibility metadata and user profiles. Following a series of localized modifications to the digital content delivery systems of each VLE the content that is appropriate for a given user profile could be presented to the user by consuming the decisions that have been supplied by the CP unit.

The ESS component of the framework requires institutional user interfaces. One of its key requirements is that it is able to represent and work with abstract sequences of workflows and

be able to cater for the occurrence of long running (asynchronous) processes such as the ordering of assistive technology (either in the form of hardware or software) on behalf of learners. During the development of the ESS, a number of standards-based modelling languages were investigated, such as BPEL and YAWL [10]. The first implementation of the ESS has been implemented in the form of a state machine which makes use of an XML-based database to store both state and workflow representations. Ongoing development is likely to explore not only different ESS designs that are particular to individual organizations but also consider whether different workflow or application engines may be utilized.

Implementing the EU4ALL framework does not only create an instance of a system that can be used to solve practical accessibility problems, the very act of building an instance allows the validity of the approach to be explored and some of its underlying assumptions (such as the application of a service-oriented architecture) to be challenged. One of the fundamental principles of the EU4ALL framework from a practical perspective is that individual institutions should be free to choose only the components that are considered to be most useful to their particular circumstances. In other words, generality, flexibility and re-usability are of paramount importance.

RESEARCH DIRECTIONS

The activity of implementing the content personalization and adaptable e-services systems has exposed a number of useful research directions:

Security and privacy

Some adaptation or personalization parameters may be considered to be private by the owners or those who are able to set or modify them. The adaptation parameters must be held in a secure way to prevent accidental or unauthorized disclosure.

Locus of adaptation control

This direction is related to the issue of security and privacy by asking the question about who (or what) may be permitted to modify or add to adaptation settings. The boundaries of who may or may not be permitted to change preferences in a teaching and learning context may be blurred. As well as an individual being able to control their settings, an administrator or tutor may be able to change learner parameters with the intention of increasing system accessibility or the ways in which services are provided.

Understanding adaptation diversity

Systems that facilitate adaptation must be adaptable themselves. Technology is subject to continual change, and new methods or parameters may be required to be implemented to take account of new requirements. In some cases, it may be necessary to consider how different systems might work together.

Adaptation architectures

There are many different ways in which adaptations can be performed. There will be much debate about what adaptation approaches are the most effective or appropriate. Different adaptation architectures will be proposed which will help to understand what is possible and desirable. As adaptation architectures mature they may become standardized. The subject of architecture helps us to ask the important questions, such as where adaptation preferences are to be held (whether they are held on a ‘user agent’ or device, or whether they are held on a

server or a number of different servers) and what may happen should adaptation preferences be unavailable.

Mobile technology

The significance of mobile devices will continue to grow in line with increasing levels of wireless internet access. The presentation of information has the potential to be customized not only in terms of end user preferences, but also in terms of the context (or location) in which a device is used, and what action is carried out.

Authoring, development and use of adaptable materials

One of the biggest challenges in developing and deploying adaptable systems lies with the ability to create alternative materials and have an understanding about how those materials will be used by individuals. The act of creating adaptable (or alternative) materials may create sets of resources that can be used by different devices in different context. Furthermore, having access to a set of complementary resources has the potential to benefit all learners.

CONCLUSION

The EU4ALL framework is a practical and a technical tool. It can be used as a lever to consider the different types of accessibility services, or elements of the framework can be translated into implementations that can help to facilitate the delivery of accessibility to learners. Alternatively the framework can be used as a lens through which a range of institutional processes that currently exist within an organization can be considered. It also provides a set of vocabulary terms and conceptual structures that enable learning technologists and practitioners to discuss the ways that an institution can support people with disabilities. The choice of which components of the framework can or should be implemented is dependent upon an institution. Its flexibility can be attributed to the application of a service-oriented architecture and the cohesion that is exhibited by some of its core units. Its ability to be implemented permits is further exploration, validation and development.

The framework has drawn upon a substantial number of face to face stakeholder interviews and from on-going work within the e-learning and accessibility standards arena. The focus of the framework has been to establish a high level view of accessibility provision within different higher educational institutions from a technical perspective. Although issues such as the checking and validation of interfaces and their compatibility with different assistive technologies are considered to be essential to the development and deployment of accessible systems, the focus of this paper has been directed primarily towards the EU4ALL framework.

It is envisaged that the EU4ALL framework will prove to be both a practical and useful tool to understand how accessibility services can be embedded within educational institutions. It is also hoped that it steps towards the goal of presenting a simple and understandable framework that aims to embody a range of different accessibility use cases, services and processes in a way that both technical and non-technical stakeholders will be able to understand.

ACKNOWLEDGEMENTS

EU4ALL is a Framework Six project funded by the European Union (IST-FP6-034778). The EU4ALL consortium comprises of ATOS Origin, CIRPS, e-ISOTIS, EATDU, Fraunhofer-Institut (FIT), Giunti Labs, Indra, The Open University, Tribal, Universidad Nacional de Educación a Distancia (UNED) and the University of York. Many thanks are extended to Jesus Boticario of UNED who has helped to guide the development and formulation of the EU4ALL project.

REFERENCES

[1] IMS Global Learning Consortium IMS AccessForAll Meta-data Overview. (2004) Available: http://www.imsglobal.org/accessibility/accmdv1p0/imsaccmd_oviewv1p0.htm

[2] Seale, J. K. (2006) E-learning and disability in higher education: accessibility research and practice. Routledge.

[3] Chisholm, W., Vanderheiden, G., and Jacobs, I. Web content accessibility guidelines 1.0. http://www.w3.org/TR/WCAG10 (1999)

[4] Norton, M., Treviranus, J. (2003) IMS Learner Information Package Accessibility for LIP XML Schema Binding

[5] Jackl, A. (2004) IMS AccessForAll Meta-data XML Binding.

[6] ISO. Individualized adaptability and accessibility in e-learning, education and training. ISO/IEC 24751 (2008)

[7] Santos O C., Boticario J G. (2008) Users' experience with a recommender system in an open source standard-based learning management system, 4th Symposium of the WG HCI&UE of the Austrian Computer Society - Usability & HCI for Education and Work (USAB), LNCS vol. 5298, Graz (Austria), Springer-Verlag.

[8] Dougiamas, M., Taylor, P.C. (2003) Moodle: Using Learning Communities to Create an Open Source Course Management System. Proceedings of the EDMEDIA Conference, Honolulu, Hawaii

[9] Santos, O. C., Boticario, J. G., Raffenne, E, Pastor, R. (2007) Why using dotLRN? UNED use cases, FLOSS International Conference, Jerez de la Frontera, Spain.

[10] Vasko, M., Dustar, S. A. (2006) View Based Analysis of Workflow Modeling Languages. Proceedings of the 14th Euromicro International Conference on Parallel, Distributed, and Network-Based Processing, 293-300.

[11] Gruber, T. R., (1995) Toward principles for the design of ontologies used for knowledge sharing. International Journal Human-Computer Studies, 43(5-6), 907-928.