A proposal for an adaptable personal learning environment to support learners needs and preferences

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In recent years, Virtual Learning Environments (VLE) (also known as Learning Management Systems) have become pervasive in Higher Education. In addition, the explosion in social software and Web 2.0 technologies raises learners' expectations of flexibility and personalisation, and highlights the rigidity and limitations of the VLE. Recognition of these limitations has given rise to the evolution of such systems into the concept of a Personal Learning Environment (PLE). This paper examines the concept of personalisation in terms of adaptation of the learning environment according to the needs and preferences of disabled learners. We report on progress towards the development of a model for an Adaptable Personal Learning Environment (APLE) that responds to the challenge of providing truly learner-centred, accessible, personalised and flexible learning.

Keywords: Accessibility, adaptability, virtual learning environment, personalization, standards, disability

Introduction

The 'traditional' Virtual Learning Environment (VLE) or Managed Learning System (MLE) has, over the past ten years, become an accepted part of e-learning provision for most Further and Higher Education Institutions in developed economies. Drawbacks to these systems have become increasingly apparent to tutors and students, mainly centred on the rigidity of the VLE in imposing a 'one size fits all' approach that may be effective to manage but limits choice, engagement and pedagogical freedom. Nonetheless, the widespread uptake of such institutional systems has increased opportunities for students to access learning support and opportunities outside of the traditional classroom or lecture theatre. For disabled students in particular, the VLE may offer opportunities to participate in mainstream education that were previously much more difficult or impossible.

The arrival of Web 2.0 has brought possibilities and expectations of flexibility and personalisation of learning that highlight the rigidity and limitations of the VLE, and has given rise to the evolution of such systems into the concept of a Personal Learning Environment (PLE). A PLE may be described as one that allows the learner to select their own components. The Joint Information Systems Committee (JISC) (JISC, 2005) describe a Personal Learning Environment as one that replaces some or all of the tools of a standard VLE with tools that are personal to the learner and integrated with the student's own personal systems and tools. The interface and tools are not designated by the institutional VLE; instead they are the personal choice of the learner.

We propose a system that takes this concept one step further; one that, in addition to the personal choice of systems and tools, is also adaptable to the needs and preferences of the individual learner, and to the environment in which they are working. An Adaptable Personal Learning Environment (APLE) would respond to the challenge of providing truly learner-centred, accessible, personalised and flexible learning, particularly, but not exclusively aimed at disabled students.

In previous papers we have reported on completed aspects of our work that individually form components of a PLE, including adaptable interfaces (Harrison, Stockton, and Pearson, 2008; Pearson, Stockton, and Green, 2005), adaptable learning objects (Green, Jones, Pearson and Gkatzidou, 2006) and a Transformation, Augmentation and Substitution Service (TASS) (Gkatzidou and Pearson, 2009). This

paper proposes a model for the development of a framework for an open source Adaptable Personal Learning Environment. The rationale for such a system is based on meeting the needs of a wide range of disabled learners who may have very different and individual access requirements (Harrison, Stockton, and Pearson 2008). The origin of this project is our experience in developing a VLE (the Portland Project) that was designed to be adaptable to the needs of a *specific* group of learners with a range of severe physical and learning difficulties.

Taken together with current research on the creation of adaptable learning objects, a personal profile tool, and an investigation of standards for interoperability, we are defining a framework for an APLE that may help to redefine the term 'universal accessibility'requirements, but could equally address the preferences of any Web 2.0 generation learner.

The components and additional processes involved in realising this vision begins with re-engineering our existing learning environment into an open source framework that will support the contribution of adaptable content, interfaces, interactions, and tools through a Community of Practice (CoP) approach. The remainder of this paper begins with a description of the Portland project, its outcomes and the limitations that give rise to this new approach; followed by an introduction to our recently completed Profile for Adaptable Learning (PAL) tool. Our proposal for a Transformation Adaptation and Substitution Service (TASS) that facilitates adaptability based on the IMS Access for All (IMS, 2004) approach is then described. The final section outlines the further work that is required to bring the APLE to fruition.

An example personal virtual learning environment: Portland

The Portland Partnership project was formed as part of the European Funded 'Equal' initiative which sought innovative solutions to the challenge of participation for disabled people in lifelong learning. The lead partner, Portland College is a national specialist further education college for learners with physical disabilities and learning difficulties, and the project involved partners from Further and Higher Education, as well as the private sector. The Partnership aimed to develop bespoke learning resources within a Virtual Learning Environment to meet the needs of young adult learners with a range of physical disabilities and associated learning difficulties. The University of Teesside was responsible for conducting an analysis of user requirements and for designing and developing the adaptive and accessible learning environment itself.

The Portland user group is young adult learners aged 16 years upwards at pre-Entry level (DfES, 2000). The differing needs and requirements of these learners make it difficult to portray a typical learner, however the Department for Education and Skills (DfES) describe these students as being "capable of learning, but they will have profound intellectual impairments and will require very specialised teaching" (DfES, 2001). The varying abilities and disabilities of this learner group suggest that each learner has unique access needs for learning. The characteristics of a learner with profound and multiple disabilities vary greatly from one learner to another, but may include:

- limited or no sight e.g. lack of depth perception or reduced visual fields
- limited or no verbal communication e.g. dysarthria
- learning difficulties e.g. low levels of literacy and numeracy
- physical disabilities e.g. poor or no fine motor skills or quadriplegia

The rationale for the project was that there were no appropriate resources designed specifically for that particular user group and no means for the learners to access any resources independently. A feature of the research was that the end users – students and tutors - were involved in the specification, design and development of the environment from the start. The first stage involved careful profiling of the individual access, control and interaction needs of this diverse group of learners.

The Portland environment (Harrison, Stockton and Pearson, 2008) took a specific and pragmatic approach to the development of an adaptable learning environment and its particular characteristics means that it could be regarded as a Personalised Virtual Learning Environment (PVLE). The tutor or administrator is able to make the required adjustments to the PVLE by selecting elements of interaction according to the individual learner profile. It was important to make the environment as accessible and autonomous as possible for the learner to facilitate independent online learning.

This PVLE then is designed so that it can be tailored to meet the individual needs and preferences of the target user group. The interface is personalised to allow learners to have the screen display and layout of

their choice, including choice of symbol set – illustrative communication aids (PCS, Rebus or Makaton) or text. This means the environment meets the needs of those learners with low literacy levels through symbol-supported text and speech output. Interaction is tailored to meet students' requirements through compatibility between the PVLE and their preferred input device (e.g. mouse, switch, scanning). The Portland PVLE includes the standard features found in most mainstream VLEs, (e.g. a secure login system, communication tools, timetable and access to tailored learning resources). However, it would not be recognizable as such to most people due to its personalised interface.

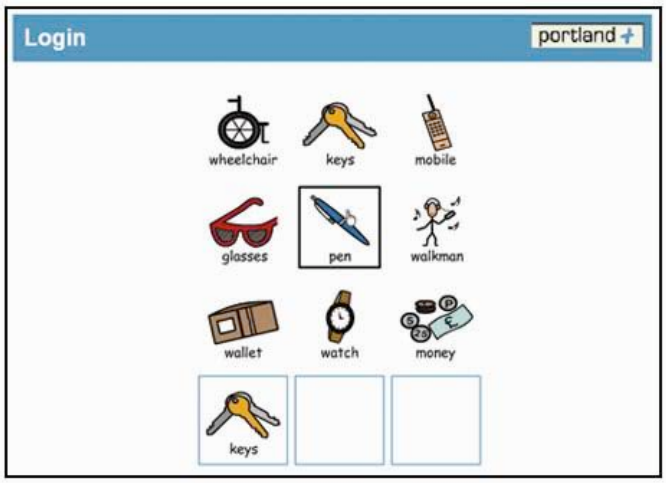

Figure 1: The Portland PVLE symbols log-in screen

Portland's unique functionality and features has resulted in an accessible and adaptable learning environment that meets the needs of learners with severe learning difficulties and physical disabilities. The design encourages a greater level of independence for the learner by ensuring that the PVLE and the learning resources are accessible with the appropriate input device, language tools and layout required by each individual user (Figure 2).

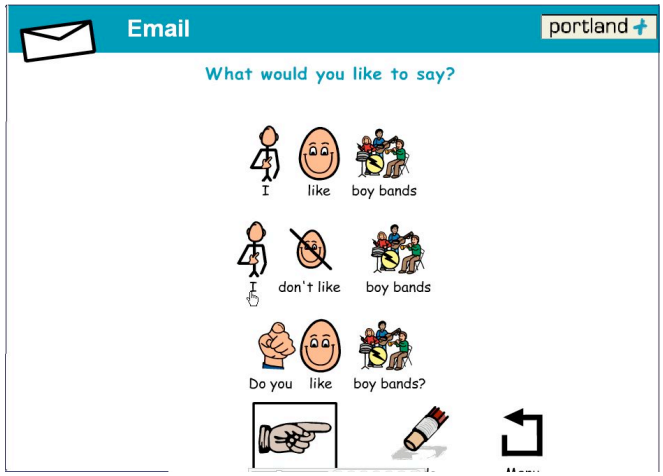

Figure 2: The Portland PVLE symbols email system

Evaluation of the Portland PVLE was carried out by video observation and structured interviews (with the appropriate ethical considerations) with some of the Portland students. The trials confirmed that the students were able to successfully and independently log in; create, send and receive emails; interact with learning materials; and view and amend (select, add and delete activities) the timetable. These results are discussed in detail elsewhere (Harrison, Stockton, and Pearson, 2008; Pearson, Stockton and Green, 2004), but they are significant in that this was the first time that these students had ever been able to independently access and interact with any computer based learning environment. Although the students understand the concept of email they had not previously been able to use the available text based systems. The bespoke learning resources addressed the problem of providing age appropriate activities at the required academic level. The timetable had previously been a paper based activity usually completed by the tutor in consultation with the student. The Portland PVLE gave these students autonomy in their learning. Typical comments from the students included:

I did it all by myself
Can I email my mum?

A walkthrough of the Portland PVLE can be accessed at
http://rime.tees.ac.uk/arc/projects/vlefeedback/indexVLE.htm .

The Joint Information Systems Committee (JISC) concept of a Personal Learning Environment (PLE) goes further in that every aspect, including the functions of the environment such as email, discussion and calendar are actively selected by the individual. In the Portland PVLE, the student access, interface and interaction requirements could be tailored to the individual and set by the tutor, but there was no substitution of components. A PLE can be developed from a PVLE if a common set of standards can be identified for component interoperability and the individual is allowed to build up their personal set of functions from available components (Pearson and Jones, 2006).

The Portland project demonstrated that a PVLE could be created that is adaptable to the needs of a particular group of learners with complex physical and cognitive disabilities and is in use by the students and their colleagues who were involved in its development. Transforming the PVLE to an open source tool, adopting the JISC concept of a PLE and incorporating aspects of adaptability would result in the creation of an APLE that could be used by many other learner groups with particular needs and preferences.

The following sections describe the approach we have taken to applying the IMS Access accessibility standards to a learner profiling tool and to the creation of adaptable learning objects.

Learner profiles

In the Portland PVLE, learners profiles were submitted direct to the system by the tutors with the profile derived from baseline observations and formal needs assessments. In an APLE the learners' characteristics will expressed, stored, retrieved and altered through the Profile for Adaptable Learning (PAL) tool.

The IMS Global Learning Consortium has developed a number of specifications (IMS, 2004), which aim to address interoperability issues among Internet-based learner information systems. The IMS ACCLIP (IMS Global Learning Consortium, 2009) specification provides a means of describing preferences so that the learners can interact with an e-learning environment, regardless of disability, hardware or environment. The needs and preferences of a user may arise from the context or environment the user is in, the tools available (e.g., mobile devices, assistive technologies such as Braille devices, voice recognition systems, or alternative keyboards, etc.), their background, or a disability, in the traditional sense. These preferences are based on those parts of a computer system (hardware and software) that can be adjusted to improve accessibility. ACCLIP describes the user in terms of accessibility needs by using a XML-based syntax. It enables the description of user preferences (visual, aural or device), which can be usefully exploited for tailoring learning content (e.g., preferred/required input/output devices or preferred content alternatives). The profile is anonymous, in that there is no need to know who the user is, or why they require the specified support. Furthermore, choices and options can be expressed as well as absolute needs; for example a user might express a preference for Braille output, but with an indicator that auditory substitution is also acceptable.

The Profile for Adaptable Learning (PAL) tool implements the IMS ACCLIP to provide an easy way for the learner to create a profile that conforms to that specification. The profile can be created, edited and modified to express the learner's preferences for appearance, layout and selection of content. The PAL interface makes it quick and easy for the user to create and store their choices. The user is presented initially with six adaptability statements to choose from and then further options are provided depending on their selection (Gkatzidou and Pearson, 2009).

Learner profile information can be used for accessibility purposes but in many instances context or preference may be equally important. For example, a non-auditory profile might mean that audio material needs a transcription and video - captions or subtitles. In broad terms there is a need to be able to define a user's contextual profile as a set of requirements for services and resources. The profile defines the user's human-computer interaction (HCI) requirements in terms of visual, auditory and tactile components. The three main elements of the profile are:

- Display or output (typically visual but could be an auditory screen reader or tactile Braille display)
- Control or input (typically keyboard and mouse but could be switches, touch-screen, joystick tactile devices or an auditory voice recognition system)
- Content (primarily visual, auditory media or textual components which can be read or transformed into auditory components by a screen reader)

In the IMS *AccessForAll* proposal (IMS, 2004) an "Adaptability" element is employed to identify a set of user needs and preferences. This is considered an important enough extension by the Dublin Core Metadata Initiative (DCMI) to consider incorporation into the Dublin Core standards itself.

In this context we accept the extension of the definition of accessibility beyond disability, and define the relationship between a user and a resource as accessible when the characteristics of the resource as delivered match the user's needs and preferences (Nevile, 2005). The definition of accessibility implied here is that the relationship between the user and the resource is one that enables the user to make sensory and cognitive contact with the content of the resource (IMS, 2004 op.cit.). According to the *AccessForAll* statement the term disability is re-defined as a mismatch between the needs of the learner and the education offered and it is therefore not a personal trait but an artefact of the relationship between the learner and the learning environment or education delivery (Cooper, Treviranus, and Heath, 2005). Accessibility, therefore, is the ability of the learning environment to adjust to the needs of all learners and is determined by the flexibility of the environment (with respect to presentation, control methods and access modality) and the availability of adequate *alternative-but-equivalent* content (Heath, Treviranus and Nevile, 2005). The needs and preferences of a user may arise from the context or environment the user is in, the tools available (e.g., mobile devices, assistive technologies etc.), their background, or a disability. Declared needs and preferences may change according to context (Nevile, Cooper and Heath, 2005; Pearson and Koppi, 2002).

Adaptable learning objects and learning patterns

In order to achieve an accessible relationship between a resource and the user, descriptions of user needs and preferences are checked against descriptions of resource components until they match. This process involves a description of a user's control, display and content needs and preferences being matched with a description of the components of the learning object (Nevile, 2005). The delivery of the appropriate component will form an accessible relationship between the user and the learning object. According to the *AccessForAll* metadata overview, accessible systems should be able to adjust the user interface of the learning environment, locate needed resources and alter resource properties to match the needs and preferences of the user. This may involve the substitution, augmentation or transformation of components of the resource such as changes in sensory modality. For our purposes we have developed a transformation, augmentation and substitution service (TASS) which is geared to a limited subset of e-learning applications and contexts. It represents a special instance of an *AccessForAll* service.

Our work to date has focused on applying the TASS to learning objects. To make rich online content match individual needs and preferences, this approach requires a basic resource to be created from existing or newly authored components, and the appropriate adaptations (transformations, augmentations and substitutions) need to be identified. Examples of these adaptations are as follows.

Transformation: Transformation may occur where text is rendered visually, as characters, or a sign language, or aurally, perhaps by a screen reader, or transformed into a tactile form as Braille or simply changed in colour, size and other display features.

Augmentation: Augmentation involves the optional addition of a feature to a primary resource, for instance a textual caption could be added to a video when required by a user with a hearing impairment or in a noisy environment.

Substitution: Substitution might occur when a user requires a vision-free access to the resource, for instance if the user was accessing the learning object on a PDA on a field trip and be accessible it is necessary to replace the visual element of the learning objects with components that match the user's preferences of vision-free access. Alternatively, an interactive exercise requiring a mouse for operation could be substituted by one that can be controlled using a keyboard or keyboard emulator for a user with a mobility impairment.

As an example a substitution occurs when a user accessing a learning object requires vision-free access to a resource, and therefore needs alternatives to the visual content contained in the primary resource of the

learning object. The profile of this user may actually be the same as the profile of a sighted user accessing the learning object on a PDA while driving: the user needs to access the learning object using non-visual techniques. For this relationship to be accessible it is necessary to replace the visual element of the learning objects with components that match the user's preferences of vision-free access. It is also often the case that the original content of the resource has to be supplemented, as for example with their availability of a dictionary or captions, for an aural component.

The use of Prolog as a TASS specification tool

As a mechanism to help designers, developers and users understand how the TASS might operate (Green et.al., 2006), a small example illustrative subset was defined using the logic based artificial intelligence language Prolog (Clocksin, & Mellish, 1984). This language has the advantages of being simple, precise, and capable of expressing both facts and rules. Facts can be thought of as explicit knowledge and information and rules as those facts which can be inferred.

One can take as an example the profiles of four representative learners:

- Peter is blind and uses a screen reader.
- Claire has a cognitive learning disability and uses switches for input and symbols.
- Angela has no declared disabilities, but states a learning style preference which marks her out as a kinaesthetic learner.
- David is deaf, and although he can read English his native language is British Sign Language (BSL).

The learner's needs and preferences can be expressed explicitly in Prolog as facts:

```
needs(peter, screenReader).
needs(claire, symbols).
prefers(david, signLanguage(bsl)).
prefers(angela, learningStyle(kinaesthetic)).
```

The fact that Peter needs a screen reader, Claire symbols, Angela is a kinaesthetic learner and David prefers BSL are stated as explicit facts.

Taking this one step further a set of facts and rules can be defined which determine what is known or can inferred about the learning objects. Taking a very simple object with just three resources (a graphic, some text and a video):

```
lo(unit1, [visual(u1p1),text(u1p2),audiovisual(u1video)]).
loResource(u1p1, primary, visual, 'graphic01.jpg').
loResource(u1p2, primary, text, 'text01.html').
loResource(u1video,primary,audiovisual,'video01.mp3').
```

The first statement states that there is a learning object (LO) called 'unit1' which uses a visual, text and audiovisual resource referred to as 'u1p1', 'u1p2' and 'u1video' respectively. The square brackets simply means expect a list of arbitrary length [a, b, .. z]. The subsequent facts simply give a little more information about the learning resources including their file names. In addition to these a number of alternative resources may be identified which can be used to augment or substitute for the primary resource e.g.

```
loResource(u1p1alt, u1p1, alternativeToVisual(altText), ..).
loResource(u1vidcap,u1video,alternativeToAudio(caption), ..).
```

Given this initial information we can then define rules to determine whether there is a mismatch between the learners needs and the available learning objects e.g.:

```
mismatch(X, LO) :-
lo(LO, Resources),
needs(X, alternativeToVisual),
member(visual(P), Resources),
Not(loResource(Equivalent,P,alternativeToVisual(Type)).
```

Given a full set of mismatch rules (including audio, audiovisual and tactile resources, language constraints, context etc.) it is possible to say that a learning object is accessible if there are no remaining mismatches between the learner (X) and the learning object's constituent primary or equivalent resources.

```
accessibleLO(X, LO) :-
    lo(LO, Resources),
    not(mismatch(X, Resources)).
```

The simple example given here does not give a full description of the power of Prolog or the complexities involved in matching learner needs and preferences to a learner object. However it does give an illustration of how accessibility, learner profiling and equivalency in the IMS AccessForAll metadata model (IMS 2004) can be handled by our TASS. The use of Prolog to illustrate the TASS in practice is further expanded in Green, Pearson, and Gkatzidou, (2009).

From adaptable resources to an APLE

One way of achieving an APLE is to extend the concept of a transformation, augmentation and substitution service to deal with the features of the learning environment as well as the content, and then to embed the TASS into the PVLE (Figure 3). This suggestion is based on the principle that learning content can be generated from adaptable aggregations of learning objects and media components using proven learning patterns. Using a variant of IMS AccessForAll (IMS, 2004 op. cit.), the TASS works on available metadata and user profiles to generate alternative, equivalent learning experiences relating to a user's declared needs, preferences and learning styles (Pearson and Jones, 2006). This might provide a more pragmatic, adaptable and ultimately accessible learning environment than the current JISC PLE concept can achieve by itself. Although the JISC PLE proposals consider the concepts of personal choice, no specific account has been taken of the work on adaptability by the IMS *AccessForAll* group. The JISC PLE proposals are based on a well recognised and understood need to make learning environments more usable for individuals or better suited to their learning and research needs. It is a small step to extend this to be more accessible by adapting both content and functions to the needs and preferences of our users.

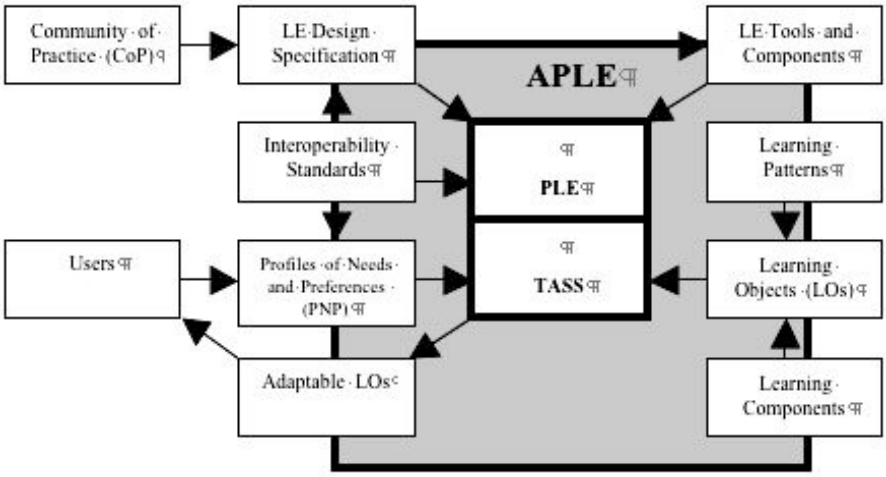

Figure 3: An adaptable personal learning environment

Further work

Current work has focused on profiling the accessibility needs and preferences of learners and on creating tools that encompass the available constituent components of learning objects. The development of the PAL tool has highlighted the fact that the IMS standards specifications do not cater (nor were they designed to) for expressing learning styles nor for the choice of delivery device.

The means for creating learning objects and personal profiles can be incorporated within the APLE and the LO components can be aggregated to deliver the complete LO to meet the learners' specifications. However, the development of many specialist components of the APLE including alternative interfaces, activities, specialised adaptations (e.g. Braille alternatives) and tools (e.g. symbols based email systems) will come from the stakeholders who form the Community of Practice. These stakeholders include developers, designers, subject specialists, learners, tutors and parents.

Further research is needed on user interface and component aspects of adaptability before a fully adaptable open source PLE becomes a reality. For example one principle of a full IMS AccessForAll service is that the alternative content or services can be provided from a number of potential sources. If a function or learning object can be identified that is better suited to the individual, in theory it can be accommodated. In practice this accommodation is fraught with problems associated with incompatibility and lack of interoperability. We have identified three specific areas of research that will turn the potential for APLE into a real prospect. Through close involvement with an already partially established community of practice, we propose to explore the potential for adaptability of learning objects, interfaces and environments. The three specific areas in which current and future work is focused are: re-engineering of the Portland PVLE; the development of learning objects and LO components to test against profiles; and the exploration of standards for interoperability.

Re-engineering the PVLE

The current Portland PVLE is being re-engineered, through engagement with an existing CoP comprised of stakeholders in further and higher education. This will establish the requirements for typical groups of users to develop a framework for an Open Source Adaptable Personal Learning Environment. This ongoing work includes carrying an evaluation of the existing PVLE in terms of requirements for alternative user requirements; gathering sample profiles of typical users from a range of user groups e.g. learning disabled; hearing impaired, vision impaired, learners with English as a foreign language; and the development of concept designs based on user requirements. This work will support the development of a technical requirements specification for an open source APLE.

Learning objects and alternative components

We are continuing to build up a bank of sample learning objects and their components for adaptability that will be mapped by the TASS against the sample profiles to deliver LOs adapted to the requirements of users, personal preferences, device or environmental needs. This is being achieved by analysing existing sample profiles and mapping the profiles against Dublin Core and IMS PNP using the PAL tool. This enables the mapping of the profiles and the alternative components against TASS to establish its adaptability capability in re-aggregating accessible learning objects.

Standards for interoperability

The third area of continuing research is to establish the existing standards pertaining to each component of an APLE for interoperability, and to identify gaps and inconsistencies. This includes identifying the range of specific standards for PLE, mobile devices, Los and interoperability. This will enable a critical evaluation of the standards in practice and an analysis of the problems, gaps and inconsistencies in interoperability. The outcome of this work will be a set of recommendation on standards for APLEs.

Conclusion

To date this project has developed a PVLE for a specific use case, a Profile for Adaptable Learning tool (PAL), an adaptable learning object authoring tool, a collection of sample adaptable learning objects and a draft transformation, augmentation and substitution service (TASS). The component elements of content, context, user needs and preferences are all considered equally important with respect to the learning environment. However central to all of this work is the learner and the resulting enhancement of the learner experience. We may not be able to guarantee an improved experience in all cases but we believe we are providing for a more inclusive definition of a PLE. The involvement of developers, designers, content experts, students and tutors, will result in the definition and delivery of a framework for an open source Adaptable Personal Learning Environment - that is an adaptable model able to grow and change according to the needs of the user. Through our collaborative approach with users involved throughout, we are confident of outcomes that offer maximum potential for wider adoption not only by disabled learner groups but within the mainstream community.

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