Fundamental Requirements of Personalised eLearning Development Environments

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Abstract:
Although personalised eLearning can offer many tangible benefits to the entire educational process such as teacher and learner empowerment [Conlan et. al. 2004] [Bajraktarevic et. al. 2003], educational community collaboration and tailored eLearning delivered just in time and just for you, several issues restrict its mainstream appeal. These issues relate to the technical coordination of building instances of such systems, the complexities of developing and composing personalised eLearning offerings and time utilization in testing and appraising the produced personalised eLearning experience. This range of issues can be addressed by identifying and representing the core fundamental requirements of personalised eLearning development environments, personalised eLearning services and the disparate design elements involved with the personalised eLearning development process. This paper will explore the core fundamental requirements of personalised eLearning development environments.

Introduction

In order for current and future generations of personalised eLearning to improve educational effectiveness and efficiency, there are fundamental requirements that must be realised. Firstly, the disparate design elements and information sources used to create personalisable eLearning must be identified, separated and modelled. Secondly, the personalised eLearning development environments must be technically transparent and standards independent. And finally the eLearning environment must be flexible and extensible in order to be durable, maintainable and extensible.

The types of information sources include pedagogic and instructional design, activities, subject matter areas, personalisation axes and learning resources as illustrated in figure 1. When these information sources are modelled, detailed descriptions about what/when/where and how the information can and should be used can be extracted. The models provide guidelines and scenario-based use cases to support the teacher in building constructive and effective eLearning experiences. Although several standards such as IMS Learning Design [IMS LD] attempt to model the pedagogical process they do not inherently prescribe guidelines for how to use the pedagogy or provide scenarios for their use.

The usability of personalised eLearning development environments is typically designed towards a specific end delivery system or a specific set of standards [Sampson et. al., 2005]. This inevitably leads to development environments that are either too system specific and technical to use or are too restricted by the constraints of the specific set of standards. Although some of these development environments allow the user to create rich adaptive hypermedia systems and eLearning offerings their appeal to the educator community will be limited since they are too complex (both technically and graphically), they do not provide pedagogical support to the course developer and they are too restrictive. Systems like My Online Teacher (MOT) [Cristea et. al., 2003] assist in developing rich adaptive hypermedia but are technically complex and offer little pedagogical support. In comparison, the Adaptive Course Construction Toolkit (ACCT) [Dagger et. al., 2004] provides pedagogy, activity, subject matter, personalisation and learning resource based support to the course developer in addressing some of the key barriers to the mainstream adoption of personalised eLearning.

The future of a functional and meaningful internet lies in web services [Berners-Lee et. al., 2001]. This also affects the future of personalised eLearning since the traditional monolithic “classroom in a server” approach will not longer be sustainable or acceptable in this rapidly growing environment. Projects such as APeLS [Conlan et al., 2002b], iClass [iClass] and KnowledgeTree [Brusilovsky, 2004a] are establishing the future of personalised eLearning in this new service topography.

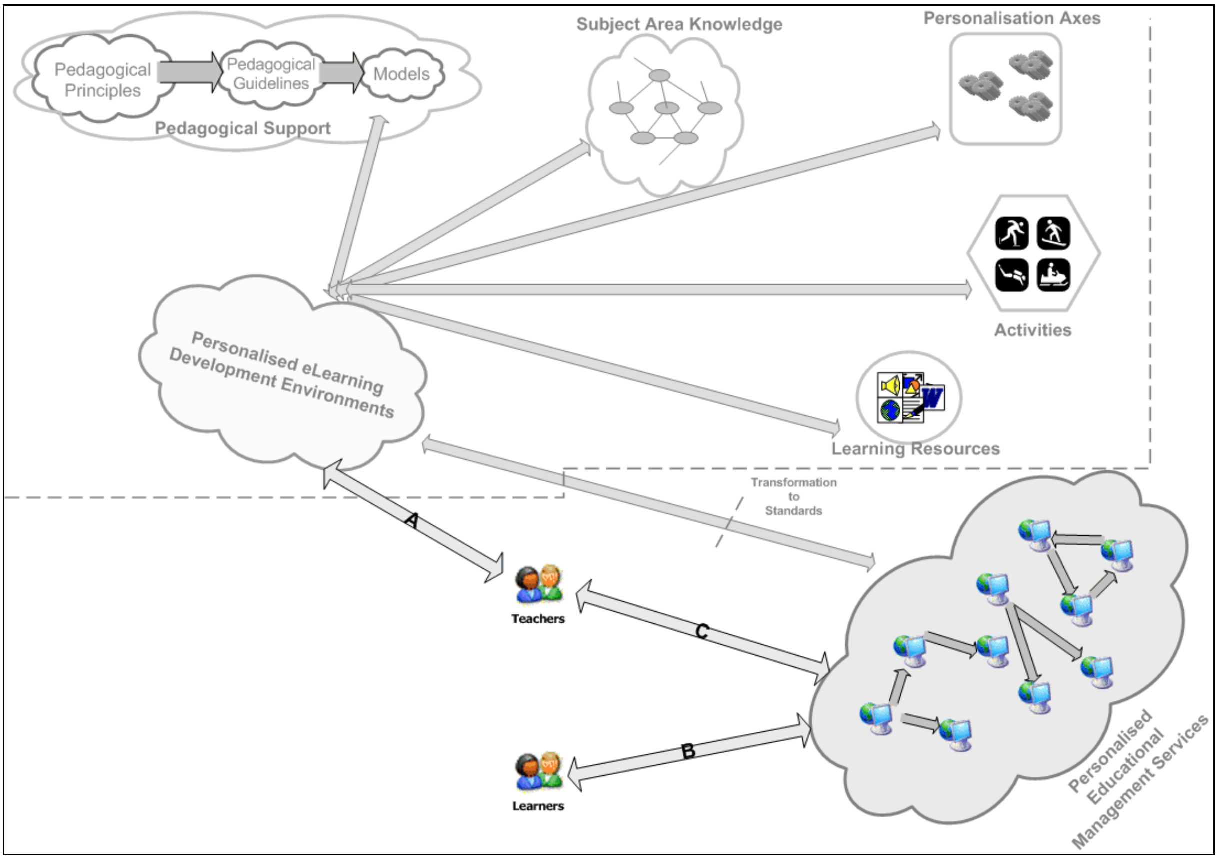

Figure 1, Personalised eLearning Space

Figure 1, above, shows the teachers (in the role of course developer) interacting (A) with Personalized eLearning Development Environments to create adaptive course offerings, which may then be personalized towards their learners' needs. This interaction involves access to a number of models used to support the authoring process. The primary of which is the pedagogical support model, which actively engages the teachers in the creation of pedagogically sounds courses. Additional models, namely the subject area knowledge, personalization axes, activities and learning resources, are also used in the creation of personalized course offerings. These offerings are transformed and *loaded* into a suitable Personalized Educational Management Service from where the learner's may engage in the personalized eLearning (B). The role of the teachers in this process is to support the learner in a mentoring/tutoring capacity during the learning process (C).

This paper will describe the disparate design elements of personalised eLearning and how they can be modelled to produce functional and reusable support structures for personalised eLearning development. The paper will illustrate the core functional requirements of Personalised eLearning Development Environments and will identify the origins of some of these requirements. The paper will then outline the service-based future of personalised eLearning. Finally, the conclusions section will outline the outcomes of this research and its future scope.

Information Models

Information models have been the intelligent driving force behind business systems, computer and software engineering systems and educational systems for centuries. The idea is to capture and represent the knowledge in an effort to increase its reusability and durability. Systems built on an information model paradigm are inherently more flexible and usable. Personalised eLearning is a relatively new field emerging from the world of Intelligent Tutoring Systems (ITS) and Adaptive Hypermedia Systems (AHS). The goal of personalised eLearning is to support e-learning content, activities and collaboration, adapted to the specific needs and influenced by specific preferences of the learner and built on sound pedagogic strategies [Dagger et. al., 2005a]. In the area of personalised eLearning, systems like APeLS [Conlan et al., 2002a] have pioneered architectures and methodologies which are built upon multi information models. These systems can then reconcile the metadata of the models when executing. This approach feeds on knowledge and is completely flexible and extensible, in essence anything that can be modelled can be then reconciled.

When this information model paradigm is applied to education, there are core intelligence sources that must be represented. This intelligence relates to pedagogy, activity, subject matter, personalisation and learning resources. A key conscious influential factor involving all information models is granularity. Granularity relates to the conceptual "size" used to aggregate the building blocks of the information model. In a pedagogical model, granularity pertains to the aggregation of the educational concepts in the model. In an activity model, granularity pertains to how fine or coarse the composite and/or atomic learning activities in the model are. In a subject matter area model, granularity pertains to the coarseness of concepts and relationships used to represent the modelled elements of that subject area. Granularity of personalisation models indicate the scoping of the parameters that the personalisation mechanisms can understand. Much work has been carried out in relation to granularity of learning resources [Verbert et. al., 2004] [Duval et. al. 2003] [Duval, 2004]. In this light, learning resources will not be explored in detail in this paper.

Other information sources such as the learner and the teacher are not covered here as we are discussing information models for personalised eLearning development environments. The learner and teacher are core information sources needed by the personalised eLearning services, however the personalised eLearning development environment does not need to either explicitly model or have accessed to specific instances of learner of teacher information. What the personalised eLearning development environment does is specify the types of information that is needed and the sources which can provide that information. For example, in an eLearning experience developed to be personalised based on a learner's prior knowledge of a subject matter area, the personalised eLearning development environment will indicate that "sections" of the eLearning experience are to be personalised towards the individual's prior knowledge of the subject matter of that "section". This provides a base schema for the learner model that is needed by this eLearning experience. This base schema can also be used to "auto-generate" a learner modelling mechanism which the personalised eLearning services can use. This approach has been successfully used by the Adaptive Course Construction Toolkit (ACCT) [Dagger et. al. 2005b].

Pedagogical

Recent trends in "personalised eLearning" indicate a core focus on adaptively retrieving rich multimedia content as a base for educational engagement [Brusilovsky et. al., 2002] [De Bra et. al., 2003]. The lack of pedagogy and activity in the learning process will inevitably lead to weak educational offerings. One of the key factors influencing this trend is the lack of pedagogical support for course developers. By making pedagogical strategies more accessible we can facilitate and promote wider use of pedagogy in personalised eLearning environments, support the course development process with pedagogically rich development guidelines and promote the sharing of pedagogy within the educational community. Recent progress in the instructional design community has lead to the creation of a design principles database "as an infrastructure for designers to publish, connect, discuss and review design ideas" [Design Principles for Educational Software]. These information sources provide valuable descriptive and usage guidelines for instructional design which could be used in the support framework for personalised eLearning development environments.

A pedagogic strategy usually consists of an arranged sequence of conceptual tasks and activities that need to be performed. This workflow is usually accompanied with best practice principals and use case guidelines to illustrate the maximum potential benefit offered by the strategy. Through a pedagogical modelling mechanism we can create an accessible and flexible instance of the pedagogy. The model contains descriptive and usage information for each of the high level concepts/activities of the pedagogical strategy and suggests a possible sequencing of these abstract elements.

The main benefit in facilitating and supporting the reuse of educational strategies is the ability to share successful and proven pedagogical approaches to personalized eLearning with the educational community. Educators can take and modify these strategies as desired, but have the benefit of a proven basis upon which those changes can be made. In this way, institutions across different countries can benefit from each others "knowledge" pertaining to teaching experiences. They may share both strategy and content, or strategy along. Through facilitating this reuse, pedagogical expertise may be shared in the same way content currently is. These mechanisms allow the strategy to be applied across educational, institutional, geographical and cultural boundaries.

There are a number of key potential facilitators to the reuse of educational strategies. The primary of these is the use of standards to represent the model in order to increase accessibility. Standards impact the reuse of educational strategies in two ways. If the strategies are written in a standards compliant format they may be utilised by personalised eLearning development environments that support the "importing" of the specific standards specification. The second impact that standards have on the reuse of educational strategies is in their description towards discovery. Strategies may be described in a similar manner or style as existing Learning Objects (LO), the associated metadata describes the use and requirements of the LO but is separated from the actual content objects. If appropriate standards are used the potential discoverability and, hence, reusability of a strategy is greatly increased.

Another key facilitator in the reuse of educational strategies is the utilization of a commonly understood vocabulary. This may take the form of either a shared vocabulary or of mappings between separate vocabularies.

This is similar to work in the area of semantic interoperability within the semantic web [O'Sullivan et. al., 2003]. The vocabulary is used to describe pedagogical concepts, activities, collaboration, services and personalisation in the educational strategy. A common understanding of these facilitates the reuse of the strategy across different personalised eLearning development environments and different personalised eLearning services.

Pedagogical strategies are fundamental to the success of future eLearning applications, in both personalised and non-personalised settings. A key enabler to promoting a pedagogically aware eLearning development community is the ability to model pedagogical strategies, making the modelled strategies accessible and promoting their reuse on a global scale. This ability to actively practice pedagogic course development should facilitate the production of more effective, active and engaging eLearning experiences.

Activity

Evolving online education requires the changing and modification of the building blocks of instructional design [Reigeluth, 1999]. In order for the learner to acquire higher order cognition skills (analysis, synthesis and evaluation), the need for instructional design which facilitates, promotes and supports activity based learning must be realized. Through online learning and eLearning we can provide a more active learning experience, promote active learner involvement and encourage self motivation.

Learning activities typically consist of some form of task(s), associated tools which could be used to perform the task(s), and appropriate learning content. Learning activities require some intuitive sequencing of operations. This sequencing describes the workflow between the sub-activities within the learning activity. These elements and attributes of learning activities can be modelled to produce an accessible and reusable form of the knowledge incorporated in that activity. The workflow information can provide the base knowledge for sequence recommendations within the learning activity model. This information, used in a personalised eLearning development environment, can support a course developer in producing activity-oriented personalised eLearning. The model should contain a description of the Learning Activity, the type of the Learning Activity (atomic or composite), the types of outcomes it can provide, the types of communications tools available and best practice guidelines on how to use the activity. This flexible modelling approach increases potential for reusability, accessibility and interoperability of Learning Activities.

Subject Matter

One of the key sources of information in any educational experience is knowledge about the subject matter area. This information contains conceptual and relational descriptions about the subject matter. The subject matter area provides scope to the personalised eLearning experience, provides knowledge to the personalisation axes and supports the course developer when designing personalised eLearning offerings. By modelling this information, the knowledge pertaining to the semantics of the subject matter area can be reused, repurposed and shared amongst the educational community. A standards based representation, in Web Ontology Language [OWL] for example, promotes the accessibility of the underlying information model.

Personalisation axes

In face-to-face learning scenarios such as the classroom or the corporate training room, the tutor or facilitator can interact with the students and perceptually gage the competency levels and the learning motivations based on those interactions and “adjust” their teaching appropriately. With standard eLearning environments these teacher dynamics are not possible since a “one size fits all” [Laurillard, 1993] mentality is applied. However a “one size fits one” approach is a more realistic. In reality different learners bring, for example, different learning objectives, different prior knowledge and past experiences and different cognitive preferences to the learning experience. This can only be accommodated by supporting personalisation of the learning experience towards the individual. Some of the different types of personalisation axes which exist are:

- Prior knowledge - based on meta information about prerequisite relationships in a subject matter area and the prior knowledge levels of the current learner, the presentation or navigation can be appropriately adapted.
- Learning objectives - this can be achieved by directing learners towards those concepts they (or the teacher) have specified as a crucial element of a specific goal. In educational scenarios where a learner is pursuing qualifications, their goals may be to concentrate on learning the essential concepts to pass an examination, whereas their teacher’s goals may be that they want the learners to become more proficient at solving certain problem types. These contrasting goals, although different in educational focus, are equally important within personalised eLearning paradigms.
- Learning history - this not only deals with the prerequisite relationships mentioned above, it also deals with existing additional knowledge, including misconceptions. These misconceptions may need different explanations pointing to connections with this additional knowledge or to differences to

already known special cases of more general topics. These explanations aim to explicitly correct existing misconceptions.

- Cultural background - for example, native language, familiar measures and weights, or specific ways of writing things (e.g. colloquial expressions). In a teaching context, this may also be extended to cover other local references, e.g. by naming well-known brands, persons, or incidents.
- Learner preferences - the environments interface is personalised towards the learner's preferences, generally determined through options or preferences menus. Learner preferences may be used to give the learner a greater sense of familiarity and comfort with the rendering interface.
- Communication style and needs - for example, learners may have a preference for clear directives versus a broader freedom of choices. This topic also includes special communication needs, for example, in the case of handicapped learners who may need special input devices with different facilities, or who may be restricted in the selection of output devices.
- Learning and cognitive styles - Learners differ in their preferred way of "learning" presentation and cognitive processing. Examples for considering different cognitive styles are visual, textual, or auditory presentation of information. Different learning styles include the presentation of examples, presentation of theoretical knowledge, and practical exercises.

These personalisation axes can then be modelled in order to represent the inherent knowledge in a form that is reusable and accessible to course developers using personalised eLearning development environments and learners using the personalised eLearning services.

Personalised eLearning Development Environments

The potential of personalised eLearning has been well documented [Conlan et. al., 2004] [Brusilovsky et. al. 2004]. However the complexities involved with creating, testing, deploying and maintaining such personalised eLearning offerings and the lack of supporting development tools have limited their applied scope. Several authoring environments exist for building adaptive hypermedia systems but they are inherently too complex and specific to be adopted by the general educational community. Within the scope of IMS Learning Design, there are authoring environments for building Units of Learning but these are again too complex and too influenced by the base standard to provide course developers with a sufficiently useable eLearning development environment.

The core goal of a flexible personalised eLearning development environment should be the ability to easily create and represent the fundamental design elements of personalised eLearning, namely, pedagogies, activities, subject matter areas and personalisation axes. For this knowledge representation to persist and be reusable, personalised eLearning development environment must facilitate the dissemination of this knowledge. For this disseminated knowledge to be useful and usable personalised eLearning development environment must provide support and an ability to compose new personalised eLearning offerings from this federated knowledge.

To drive personalised eLearning into the mass market, personalised eLearning development environments that are built upon proven course composition methodologies are needed. These personalised eLearning development environments are fuelled by the accessible information models previously defined and provide support to the course developers on all aspects of personalised eLearning development, such as pedagogy, subject matter, activities, personalisation and learning resources. The personalised eLearning development environment therefore reflects a proven methodology and not the underlying models or standards that might be used to achieve the personalised eLearning. If the methodology of personalised eLearning development changes slightly, this reflection in the personalised eLearning development environment will be minimal since the addition of information sources fits with the paradigm of a multi-model meta-data driven approach [Conlan et al., 2002a] to personalised eLearning that the personalised eLearning development environments is based upon. This system flexibility will dramatically lower the maintenance costs of such personalised eLearning development environments. Also, another key benefit of this approach is the ability to transform. By keeping the base currency of personalised eLearning development environments in a canonical form, its ability to be transformed into various different forms becomes apparent. The transformation process can produce, for example, models that conform to certain standards such as OWL for the subject matter area, LD for custom pedagogy and activity and IMS Content Packaging [IMS CP] for exporting developed learning experiences. This canonical form does not impede but enhances the flexibility offered to the course developer and provides an independent storage mechanism for the multiple information sources.

Personalised eLearning development environments must support multi information sources by facilitating access to local and remote information repositories. Based on this they should support the creation, customisation, importing, exporting and publication of all the supported information models required by the personalised eLearning service. The personalised eLearning development environments should also use the modelled information to provide the course developer with contextual guidelines for effectively building personalised eLearning from the information models.

The Adaptive Course Construction Toolkit (ACCT) is a design-time tool which allows the course developer to create adaptive and non-adaptive activity-oriented eLearning experiences based on sound pedagogical strategies in a developer-supported environment. The ACCT provides the course developer with such tools as concept space/domain ontology builder, custom narrative builder, content package assembler, learning resource repository interactivity and a real-time course test and evaluation environment. The architecture of the ACCT is built upon a reusability-focused, developer-supported and service-oriented architecture. For example, the ACCT allows the course developer to interact with the learning resource repository, searching for candidates based on keywords and contextual prior use, through a web-service interface.

Personalised eLearning Services

Specifications that support the adaptation of learning content such as IMS Learning Design (LD) and Simple Sequencing are designed to give Learning Management Systems (LMS) a common model of adaptivity to support. By including this support in LMSs the system will be able to support content that includes such adaptive learning paths. However, this approach to personalization is flawed on two accounts. The first is that the LMS vendors have shown that when a specification is open for interpretation they will often implement subtly different flavours of the standard. This is due to the specifications including a number of *optional* elements and the vendors wanting to differentiate their product from their competitors. This was certainly the case with the adoption of LOM in many systems. The second flaw in requiring LMS vendors to implement these specifications is the rate of change at which our understanding of online pedagogies is evolving. By committing to specifications that are limited in how they support pedagogy and in the mechanisms available for modelling learners the possibilities for personalized eLearning may be curtailed. From an authoring perspective having LMSs support adaptivity is undesirable as in the first instance the author may have to create different versions of their content to support the lack of uniformity in how the LMSs support the standards. In the second instance the adaptive course author is constrained by the learner information available upon with their content may adapt. This concern holds true for adaptable content, also, as again the author may not have a consistent set of tools available to the learners for controlling the adaptability of content.

There is a solution to allow LMSs to support adaptivity, if indirectly. Through the provision of personalized eLearning services and a common (and simple) service interface to them LMSs may invoke these personalized services. This approach alleviates the LMS vendor from including additional components in what are often already bloated monolithic. If they wish to have support for specifications, such as IMS LD, then they may utilise a service to *play* content supporting these specifications. If course authors wish to support more expressive forms of adaptivity then they too may make their personalized offerings available as services. The service oriented approach shifts the responsibility for adaptivity from the LMS to the service supporting the adaptivity. The data flow between the LMS and the service can be minimal. At a minimum learner identification and authentication information should be passed to validate that they may access the course (although this may occur at the LMS side) and support single sign on.

This is the approach that was taken in the European Commission EASEL FP5 project where an early version of APeLS [Conlan et al., 2002b] was made available as a service [Conlan et al., 2002a]. This service was invoked remotely by a commercial LMS using a modified version of the AICC Content Interworking specification. This approach was taken as web service technologies were still in their infancy at this stage. The benefits brought by this approach are that the remote adaptive service could create personalized courses and model learners without placing any additional requirements on the LMS. The service became a personalized eLearning service. The challenge that was not addressed in this work is that of allowing the personalized eLearning service to utilize collaboration, assessment, etc., tools from the LMS.

KnowledgeTree [Brusilovsky, 2004a] describes a framework of services [Brusilovsky et al., 2004a] that may be used to support personalized eLearning. The KnowledgeTree approach supports the disaggregating of LMSs into a suite of constituent services. This approach helps to alleviate the problem often faced by LMS customers of choosing the most appropriate LMS for their needs. For example, a customer may prefer the assessment features of Blackboard [Blackboard] and the learner management tools of WebCT [WebCT]. If these separate elements of the systems were available as services the customer may assemble the LMS that best suits their needs. An additional benefit of this framework is the possibility to include personalized services at different points in the Portal, which all of the services are accessible through. For example, the Portal may include not only personalized eLearning services, but also personalized learner management and course management tools. The difficulty with the KnowledgeTree approach is achieving agreement between the various vendors in the eLearning space on the communication protocols and specifications to enable such a service oriented approach.

In the shorter term there is a solution being explored by the European Commission iClass FP6 [iClass] project. This project is adopting a service oriented approach where all of the modules responsible for personalized eLearning are implemented as web services. There are services responsible –

- for the profiling of learner preferences (Profiler)
- the monitoring of learner knowledge state (Monitor)
- the selection and personalization of learning concepts (Selector) [Brady et al., 2005]
- the creation of tailored learning objects (LO Generator) [Brady et al., 2005]
- the presentation of personalized learning activities (Presenter).

These services integrate, in a light weight way, with a commercial learning management system via a standard feature of the LMS to include external web pages. The services, and in particular the service responsible for presenting the personalized learning activities, are capable of invoking collaboration tools available in the LMS using web services. This approach, while different from that of KnowledgeTree, can still achieve the appearance of deep integration when, technically, the integration is light. There are two key services in iClass that support this. The first is the Conductor service which is responsible for instigating and controlling workflows across the other iClass services and the LMS. The second key service is the Presenter module, which is responsible for delivering not only the personalized eLearning, by also for delivering web page components of the other services, e.g. the elements of the Profiler responsible for gathering learner preferences or the prior knowledge tests from the Monitor.

The services of Selector and LO Generator are both based on Adaptive Engine 3 (AE3), a generic and extensible adaptive engine based on APeLS. AE3 supports the runtime reconciliation of disparate models using narrative, which is the embodiment of adaptive logic. AE3 may be used to produce a large range of different adaptive effects. Using the Selector and LO Generator as example the personalization achieved in both systems is quite different, yet they are both based on the same fundamental engine. The genericity and extensibility of AE3 are key in the production of different adaptive services. From an authoring perspective this extensibility may be leveraged by creating/using any model the author requires. This level of flexibility is not possible in LMSs or heavily integrated solutions and is facilitated by a service oriented approach, where each service can operate with a certain level of autonomy.

Conclusions

For personalised eLearning to be successful there are several core areas which need to be addressed and in some cases re-addressed. Course developers need to be empowered with usable tools to efficiently and effectively create personalised eLearning offerings. They need to be supported by the tools and information models that feed the tools in the core areas of course development, namely pedagogy, activity, subject matter, personalisation and learning resources. This support framework is achieved through the application of a multi-model metadata-driven approach and the separated modelling of the core information models required for personalised eLearning development. The personalised eLearning offerings created in these development environments will be used in personalised eLearning services which will support the teachers in facilitating the learning process and support the learners in engaging the learning experience.

This paper illustrated the fundamental requirements of personalised eLearning development environments. It outlined and described the required information models that are required to both build personalised eLearning and also deliver personalised eLearning. It described the requirements for personalised eLearning development environments in order to be flexible and acceptable. It then illustrates the future scope of personalised eLearning in a service oriented web.

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