Experiences with GRAIL:

Citation for published version (APA):

de la Fuente Valentin, L., Pardo, A., & Delgado Kloos, C. (2007). Experiences with GRAIL: Learning Design support in .LRN. In T. Navarrete, J. Blat, & R. Koper (Eds.), *Current Research on IMS Learning Design and Lifelong Competence Development Infrastructures* (pp. 33-39). Universitat Pompeu Fabra.

Document status and date:
Published: 12/08/2007

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Current Research on IMS Learning Design and Lifelong Competence Development Infrastructures

Proceedings of the 3rd TENCompetence Open Workshop

Barcelona, Spain, 21st and 22nd June 2007

Edited by Toni Navarrete, Josep Blat and Rob Koper
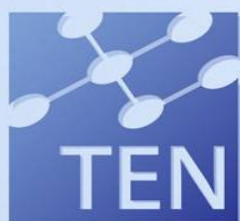
TEN Competence

Building The European Network for Lifelong Competence Development

Current Research on IMS Learning Design and Lifelong Competence Development Infrastructures

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Introduction

These proceedings consist of the papers presented at the Third TENCompetence Open Workshop which were accepted after peer reviewing. The workshop theme was Current Research on IMS Learning Design and Lifelong Competence Development Infrastructures. The workshop took place at the Universitat Pompeu Fabra, Barcelona, Spain, on the 21st and 22nd of June 2007.

TENCompetence is an Integrated Project funded by the EU 6th Framework Programme, which runs for four years from December 2005. The aims of the project are to develop a European, open-source infrastructure that will support the lifelong development of competences. More specifically the infrastructure will enable individuals, teams and organisations to:

1. Create formal and informal Learning Networks in different professions and domains of knowledge.
2. Assess and manage the competences that are acquired at any stage in life by the participants of the Learning Network, taking into account that people have learned from many different formal and informal learning sources.
3. Stimulate the reflection on the current competences to support the formulation of new learning goals.
4. Search for adequate formal and informal learning resources to build new competences or to update existing competences in a profession or domain of knowledge.
5. Provide the actual learning environment that is needed to perform the learning activities.
6. Provide effective and efficient support to learners.
7. Support the sharing of learning resources.

To meet these needs the project has developed a domain model for Lifelong Competence Development. This has been implemented in a client-server system called the Personal Competence Manager (PCM) which enables individuals, groups and organisations to manage the whole range of their lifelong competence development activities. The system integrates a number of existing open-source applications, together with the outcomes of research and development work carried out by the project into models and tools for:

- Knowledge resource sharing and management
- Learning and assessment activities
- Competence development programmes
- Networks for lifelong competence development

A key part of the strategy adopted by the project is the use of open-source licenses for all software which is adapted or developed for inclusion in the TENCompetence system, and publication of all models and other relevant documentation under Creative Commons licenses. To make this strategy effective, the project promotes public engagement with the research which it undertakes through a series of public workshops. These are of two

types. Firstly, the project organises its own open workshops, each with a theme related to the research being undertaken by the project. The first of these was held in Sofia, Bulgaria, in March 2006, and the second was in Manchester in January 2007, while the third one in Barcelona led to the production of these proceedings. Secondly, the project collaborates with other organisations to set up workshops which address related issues, as was the case with the joint PROLEARN – TENCompetence workshop at EC-TEL 2006, at ICALT 2006, and at e-Portfolio 2007.

The project also organises an annual winter school, where PhD students are invited to become part of the TENCompetence research community. The proceedings of all these events are available from the TENCompetence public Web site[1].

The area of Lifelong Competence Development is extremely wide, as it includes (among other aspects) informal learning, professional development, higher education, competence based approaches, assessment models, learning design and IMS Learning Design (LD), and personal development activities of all sorts. As might be expected, the issues raised by the provision of a technical infrastructure to support this wide field are also wide ranging, including Service Oriented Architectures, programming frameworks, open-source organisational models, interoperability specifications, domain models, Personal Learning Environments, competence frameworks.

Within this wider context the theme chosen for the Barcelona workshop was Current Research on IMS Learning Design and Lifelong Competence Development Infrastructures. UPF, the local organiser, had been coordinating the UNFOLD project[2], supporting the uptake of IMS Learning Design, which set up an international community all over the world around it. Thus, the workshop aimed at providing an overview on current research on IMS Learning Design (LD) in relation to competence development. The workshop call asked for papers on:

- Development of LD tools and architectures, eg, editors, content management systems, runtime engines
- Advanced applications of LD (eg, in gaming, collaborative learning, competence development, ePortfolios)
- Research and technology development to support users in creating an adequate learning design (e.g. software agents or design aids)
- Research to evaluate the ability of the LD specification to integrate the following criteria: completeness, pedagogical flexibility, personalization, re usability, formalization, etc.
- Evaluation of the use of LD in practice, including the integration of a variety of specifications in a learning environment
- Positioning LD in the wider context of learning, training and instruction, or definition of the current state-of-the-art in LD
- LD for formal and informal Lifelong Learning and Competence Development

Due to the growing relevance of Social software and Web 2.0 services, the call mentioned that this could be an approach underlying those specific issues.

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[1] http:// www.tencompetence.org
[2] http://www.unfold-project.net/

The papers included in the Proceedings have been grouped into the same thematic sections which were established for the programme of presentations at the workshop. Two sections had the largest number of papers, namely *Learning Design* and *Assessment and monitoring*, while the sections *Pilots, Repositories and Metadata*, and *Learning paths and competence frameworks* had less papers accepted. On the whole, 12 papers which made a very interesting workshop for the attendees; most contributors came from Spain, as might have been reasonable to expect.

The Editors:
    Toni Navarrete
    Josep Blat
    Rob Koper

    Barcelona, Spain, January 2008

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LEARNING DESIGN

Extending IMS Learning Design services using Widgets: Initial findings and proposed architecture

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Abstract: IMS Learning Designs provide a specification for the activities undertaken by learners within an environment; currently the definition of the environment is typically a set of web resources and files, with the potential to add two basic types of tool: conferencing and mail. In this paper we describe our initial findings on using a lightweight approach to the addition of small applications ('widgets') to the palette of options available for Learning Design environments.

1 Introduction

IMS Learning Design is a specification aimed at supporting a wide range of pedagogical scenarios, whereby a teacher or designer specifies a set of activities and the environment in which they take place. The environment involves content, such as web pages and documents, but also what the specification calls *services*. Services are intended to designate interactive tools in an environment that support a particular activity.

At the time the specification was developed it was imagined that such services would be provided as part of a single integrated system that 'ran' the learning design. For example, a Learning Management System with an integrated forum and chat system.

However, the emerging concepts of distributed eLearning systems, such as personal learning environments [1] suggest that instead the services supporting an activity may be relatively autonomous small applications. Also, the range of services defined within the specification is very limited and would benefit from being extended to support a much more diverse set of tools.

Two possible architectures can be envisaged that allow for the use of a richer, less closely bound toolset. Firstly, there is the model of using a local framework for the instantiation of tools within a managed environment. Second, there is the use of a wider framework to incorporate tools distributed across the web.

2 Local tool frameworks

The LAMS [2] system offers a much richer tool environment than conventional Learning Design-compliant systems. This uses standard Java deployment conventions to provision

the tools in the environment, and a local API to integrate the tools with the runtime behaviours and also the authoring environment as a single system.

Widget engines such as Apple Dashboard [3], Windows Vista Sidebar [4], and Yahoo! Widgets [5] employ a similar approach with a tool packaging format, local API, and a deployment environment. These technologies are the focus of new standardisation efforts by the World Wide Web Consortium [6].

Advantages of local frameworks:

- Conventions make it easier to develop new tools

- Consistent deployment and management for administrators

- Obviate the need for an identity framework – tools are able to use the local security context to acquire any user information which policy allows

- Tools tend to be smaller and focussed on a single purpose rather than larger with lots of overlapping features, making them easier to fit to role within a learning design activity

Disadvantages:

- Tools must be deployed and managed in a single location

- Tools tend to be restricted to a particular programming language; in the case of LAMS this is Java; in widget engines it tends to be JavaScript

- Tools are generally limited in size and complexity; usually this is a benefit but can be a disadvantage where complex functionality is needed

3   Remote tool frameworks

Remote tool frameworks are very much dependent on the identity architecture that enables tools to obtain information about users and launch context across the network in a manner that respects privacy concerns and does not expose the system to unauthorized snooping. Currently, Shibboleth [7] provides one such framework, as does OpenID.

Overall, the authors have so far not identified an existing working system, although several developments are underway, such as the IMS Learning Tools Interoperability specification [8].

Advantages of remote frameworks:

- Tools can be developed using any programming language

- Tools can be much larger than a simple "widget"

Disadvantages:

- Distributed security and privacy issues need to be tackled

- Tools will generally need to be larger and more complex, as fewer concerns are delegated to the framework

- Tools will tend to offer more features, but by doing so create issues of overlapping functionality, making them less easily repurposed within learning designs

Given this state-of-the-art, the authors decided to investigate the use of the widget engine approach for learning design tools.

4 Widgets

Widgets can be described as a type of single-purpose application, which rather than operate in a completely standalone fashion instead is deployed within a framework that handles basic functions and services. Today, there are two distinct types of "Widgets" in common usage.

Widgets on the desktop

The term "widget" for this type of application was initially used in relation to the Konfabulator platform for Mac OS X and Windows operating systems, originally conceived by Arlo Rose in 1998 and released in 2003 [9]. Konfabulator provided a layer within which lightweight applications could float over the users desktop. Unlike traditional applications, Konfabulator "Widgets" were very easy to write, having more in common with "skins" over Internet services than full desktop applications, and a very large base of third-party widgets quickly sprang up. Typical widgets included News aggregators, clocks, calculators, calendars, desktop notes and weather forecasts (see Figure 1).

Figure 1. Typical Widgets

In 2005 Yahoo! acquired Konfabulator. Around the same time, Apple released Dashboard, a Widget engine built into Mac OS X [3]. Microsoft in 2007 released SideBar, a Widget engine for Windows Vista [4].

Each of these Widget platforms had certain common features:

- Widgets typically have a user interface defined using HTML and CSS, just like a web page (Yahoo! Widgets uses a proprietary XML format very similar to HTML)

- Widgets have business logic written in JavaScript

- Widgets are packaged with a metadata manifest that describes how they should be instantiated by the Widget engine

- The Widget engine offers an Application Programming Interface (API) for enabling Widgets to store and retrieve user preferences, make use of network facilities and, in some cases, operating system facilities such as the command shell [10]

- The Widget engine renders Widgets and handles Widget interactions, typically as a layer associated with the user desktop

These characteristics make developing Widgets relatively simple for the developer, and a very large number of Widgets have been developed. At the time of writing, 2960 different Widgets have been written for Apple Dashboard [11].

As the number of Widget engines has increased, interoperability of Widgets across different engines has emerged as a problem; for example, Widgets written for Apple Dashboard will not work on Windows SideBar as the two Widget engines use very different APIs for accessing the framework. In response to this, the World Wide Web Consortium (W3C) began work on a standard for Widgets. At the time of writing an initial requirements draft has been produced [12] which sets out the general direction of the group, and in particular identifies aspects of Widgets that might be standardised:

- The packaging format used to encapsulate and distribute Widgets

- The media type used for Widgets

- The structure of the manifest used to describe Widgets

- The scripting interface (API) used by Widgets to communicate with the Widget engine

Web widgets

While Widgets on the desktop have attracted the most attention initially, there has also been a parallel development of Widgets for the web. Typically this means small chunks of web functionality that have the facility to be embedded in other web applications; for example, adding an instant messaging tool to a weblog to enable live interaction with visitors. As with desktop Widgets, a number of Widget engines have emerged to provide a platform for multiple Widgets to be coordinated; these include Netvibes [13] and PageFlakes [14], and just like their Desktop counterparts offer an API for interacting with the framework (see Figure 2.)

Figure 2. Netvibes, a Web widget engine.

Overall the development of Widgets on both the desktop and the web has been part of a trend towards the convergence of web and desktop application architecture.

Collaboration widgets

Desktop Widgets and their supporting engines have been developed in response to the need from users to access discrete chunks of functionality in a simple and fun way, but exclusively from a single-user viewpoint. While there are "chat" widgets, these operate by providing a façade onto a complete desktop communication tool such as iChat [15]. Widget engines are very much personal rather than shared infrastructure, and there are no mechanisms to share a dashboard or a sidebar amongst users.

Web Widgets have followed largely the same route, however the Widget context – whether engines like PageFlakes or individual blogs – is a public space, and so there is more scope for collaboration. A number of collaborative web widgets have been developed, such as the chat tools Gabbly [16] and 3Bubbles [17].

Widgets and Learning Designs

Widgets have a number of properties that make them of interest in extending Learning Design. First, the large number of existing Widgets and their ease of development offer a potentially effective way to enrich a Learning Design platform with new functionality. Second, while there are relatively few collaborative Widgets today, a Learning Design framework offers a context where such Widgets may be usefully developed. Finally, Widgets provide a very attractive and interactive user interface that could improve engagement with Learning Design-based systems. The authors feel that Widgets offer an interesting new take on adding interactive features to learning designs, and one which could be implemented in a relatively straightforward fashion building on existing tools and conventions.

5   Proposed architecture

The approach investigated by the authors uses a Widget engine (the Widget Server) as an add-on to an existing Learning Design runtime system, in this case the CopperCore engine [18] combined with the SleD rendering layer [19]. The Widget Server, like a desktop or web Widget engine, offers a scripting API for widgets, and is responsible for instantiating Widgets required by users within the presentation context (See Figure 3.)

The overall design follows the initial work of the W3C Widgets specification combined with aspects of the Apple Dashboard Widget API, but is applied within a web context rather than a desktop context. This has some particular implications for the design, as described later in this section.
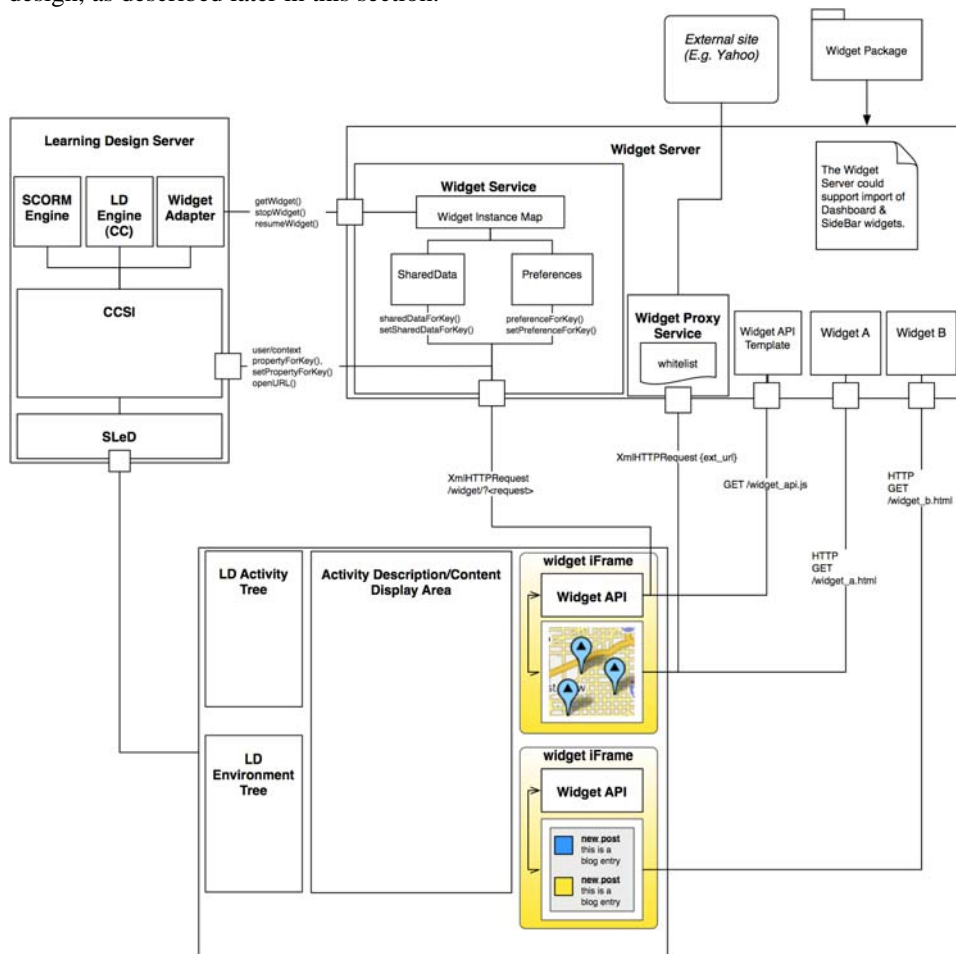
Figure 3. Overview of the architecture

Widget Invocation

The flow of events begins with the rendering by SleD of an environment for a user. SleD invokes the CopperCore Service Integration component to obtain the rendering of the environment. In addition to the existing handlers, a special WidgetHandler is included that is responsible for handling Services of the "Widget" type. This handler invokes the Widget Service and requests a new Widget instance URL from the engine that can be loaded into an iFrame by SLeD. The URL contains launch context information in the form of an opaque hashcode, and an API key that identifies the Widget when it calls the API.

Note that, unlike in LAMS, where tools are explicitly defined within the learning design during authoring, in this architecture the designer only indicates the types of Widgets needed within parts of a design using an extension to the Learning Design Environment construct, similar to the existing "service" element. The actual Widget implementation used is dynamically determined when the design is run. Any dynamically extended system – including both LAMS and a Widget-based application - have to gracefully handle the absence of a specified tool in a given instance; we propose using simple widget type descriptors ("chat", "voting") rather than specific widget identifiers in the design itself as a way of enabling the implementation to locate an appropriate widget. This is especially important where the design is authored in one environment and deployed in another.

Widgets obtain their initial state via calls to the Widget API (q.v.), which can include requests for particular learning design properties, which might include Widget-related settings. This represents a "late binding" approach in contrast with the LAMS "early binding" approach[1].

Widget API

As the user interacts with the Widget in their browser, the Widget's JavaScript logic is able to interact with the Widget API, which is provided to the Widget as a JavaScript library. This API offers a range of capabilities, including callback events for responding to external events (e.g. the Widget being locked, or shared state updated by another user), accessing and saving user preferences, shared states, and global properties.

Each of these capabilities is utilised by accessing the Widget JavaScript object. As all interactions between a Widget and the Widget Service via the API are made using AJAX, the architecture is entirely asynchronous. This means that Widgets must be constructed using event callback handlers.

Installing Widgets

The Widget Server offers a facility for installing new Widgets so they are made available for use in learning designs. This could make use of a number of import routines, for example to enable the installation of Widgets that conform to the W3C Widget Specification (when it becomes available) or in other conventional formats such as Apple Dashboard Widgets, Windows SideBar Gadgets, and Yahoo! Widgets. These must be

categorized when registered with the server so that Widget requests from CCSI can be matched with an appropriate Widget.

Widget Proxy Service

Modern browsers enforce a *same origin policy* [20] to prevent cross-site scripting attacks taking place, whereby information within one browser context is communicated to a different website without the user's knowledge or permission. This has the side effect of making calls from a Widget to a remote data source, such as an RSS feed, impossible. To get around this restriction we place a server-side proxy within the same domain as the Widget Server that Widgets can call instead. The proxy routes requests from valid Widgets to remote sites and passes through their responses. This routing can be supported with filtering rules such as blacklists and whitelists.

Locking and unlocking Widgets

One of the key differences between the proposed solution and the standard Widget engines is the ability for a Widget to be locked. A locked Widget is no longer able to set any preferences, shared data, or learning design properties. This is important when, for example, a learning design involves a collaboration session where the outcomes are used for assessment; the teacher needs to be able to freeze the content of the tool (e.g. chat, discussion, whiteboard session) so that it can be used for the assessment activity. This is supported in the architecture at two points: within the Widget API, so that it can be invoked from a Widget itself, and in the Widget Service, so that it can be invoked from CCSI in response to evaluating the state of the learning design itself. In the latter case this would most likely be where a Widget is locked after a user has completed the activity it is involved in.

Security and privacy

The use of an opaque hashcode for contextualisation obviates any need for the transmission of user information across the network; likewise the use of an iFrame for placing the Widget within the browser prevents cross-site scripting attacks, and the Widget Proxy Service enables the server administrator to prevent loading of remote malicious code. By locking Widgets after their activities are completed, the possibility of brute-force attacks on Widget instance hashes is also minimized. Overall the solution seems to fit well with modern approaches to privacy and security.

6   Initial experiments and future work

Current implementation

Our initial work has focussed on testing individual aspects of the architecture, such as the API callback methods, and server structure. Initial implementation work has begun using a Java servlet for implementing the Widget Service with a number of test widgets being developed including Chat, Voting, and Discussion Topics.

Additionally we will be trialling the use of existing Widgets from other engines, such as Apple Dashboard, within the system to support learning designs. This opens up some interesting possibilities; for example, adding Widgets such as unit conversion, RSS aggregators, calculators, and searchable dictionaries to support learning activities.

Monitoring and intervention

One of the special requirements of Widgets within a learning design context is the need to monitor both the individual shared state of multiple instances of a Widget within a single context – for example, the progression within a simulator Widget, or the content of a group chat. Linked to this is the requirement to support moderation and intervention, such as inserting a hint, or deleting unpleasant contributions. Currently we envisage this type of monitoring and intervention as occurring in one of two ways: either specifically incorporated within a Widget, and activated using the method for requesting LD properties (e.g. display the monitoring controls when the user's role is teacher or moderator), or directly through an interface onto the Widget Server itself. The latter is much simpler in architectural terms, although the concept of a single user interface for monitoring very different types of Widget activities may be difficult in practice.

7 Conclusions

While this work is still at an early stage we feel that there are many possibilities offered by this approach that could enrich the capabilities of Learning Design systems. The architecture being developed has been able to leverage much of the work of W3C in its specification efforts, and also the implementations of Apple, Microsoft and others provide a set of reusable conventions that have assisted in the development of the framework. However, we have also identified from LAMS and other work the areas where the framework needs to go beyond the conventions of current widget engines to offer the functionality required to support learning designs, such as collaboration, monitoring, and intervention. We hope to demonstrate in the near future a complete working system that uses single-user widgets developed for existing widget engines alongside new collaborative widgets within a learning design environment.

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Design Principles for LAMS Version 2 and the LAMS "Tools Contract"

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Abstract: In this paper we discuss the design and implementation of LAMS Version 2. We start by giving an historical perspective and introduce the requirements that were gathered by the users of previous versions of LAMS. The requirements collected focused on improving pedagogical support and reusability; enhancing collaboration among educators; improving the user interface and overall user experience; and to providing greater robustness, scalability and reliability

Based on these requirements, we present the proposed LAMS 2 Architecture and introduce the LAMS Tools Contract, which shows a way to integrate modules or tools within the LAMS Core "Workflow engine".

In addition we explain the steps required to implement the LAMS Tools Contract for new activity tools as well as integration of external tools via a "tools wrapper" so they could be integrated with the LAMS framework. The LAMS Tools Contract also provides a set of innovative functionalities that could inform the next generation of interfaces between e-learning platforms and activity tools.

1   Background and Introduction

LAMS (the Learning Activity Management System) is a system for educators to author learning designs using a drag and drop interface, as well as run these designs with learners and monitor learner progress. Initial LAMS development began in 2002, and a live prototype was first demonstrated at the Valkenburg group meeting in Vancouver in February 2003 (Dalziel, 2003a). It was subsequently trialed in a range of university and school contexts in 2003 and 2004, with the Version 1 release in December 2004 (LAMS Foundation, 2004), followed by the release of LAMS as open source software in early 2005 (LAMS Foundation, 2005a).

While LAMS was "inspired" by Educational Modelling Language (EML) and IMS Learning Design (IMS LD), its initial focus was on activity tools for learning design, not as a reference implementation of EML or IMS LD. Although the initial development of LAMS attempted to implement IMS LD, a series of challenges meant that this was not achieved in the first version (Dalziel, 2003a; 2003b).

A number of formal evaluations of LAMS have been conducted, such as the JISC (Joint Information Systems Committee) trial of LAMS in UK higher and further education (Masterman & Lee, 2005) and the BECTA (British Educational Communications and Technology Agency) evaluation of the UK Specialist Schools Trust trial of LAMS (Russell, Varga-Atkins & Roberts, 2005), as well as other research and evaluations (for example, see the list at LAMS Foundation, 2005b).

Complementing the LAMS software is the "LAMS Community" (LAMS Foundation, 2005c), an online community of practice for LAMS users to discuss the use of LAMS and share LAMS learning designs through a repository (Dalziel, 2006). In addition to the advice from formal evaluations such as those described above, LAMS users have provided extensive feedback through the LAMS Community forums and through personal contact with LAMS developers.

While many educators and learners have used the first version of LAMS to create impressive learning designs and experience rich online learning environments, their use has encouraged them to request further features and improvements.

Additionally, as the LAMS application was originally created as a proof-of-concept, the system lacked a clear specification or blue-print. Moreover, due to the high demand for new features in LAMS, the early development team started to increase the code base without a sufficiently robust architecture that could scale to handle hundreds of simultaneous users.

Most importantly, the experience of using LAMS led educators to request fundamental new features, such as: the ability to edit a lesson (or unit of learning) while it was running with learners; an activity tool "plug-in" architecture that supported easy development and installation of new tools; branching within learning designs; use of media types other than just text (videos, audio, etc); the ability for learners (and educators) to export a comprehensive record of learning ("portfolio export") out of LAMS, internationalisation to support languages other than English, etc. The combination of a need for a scalable architecture together with support for a wide range of fundamental new features made it clear that a new version of LAMS was needed.

2   Requirements for a new LAMS

While the educational concept of LAMS was sound, key areas for improvements were identified based on numerous consultations and feedback from educators and users.

These areas can be summarised as:
- Pedagogical support and reusability
- Collaboration
- Usability and interface
- Technical improvements

Each of these areas is described in detail below.

Pedagogical support and reusability

As part of improving LAMS' pedagogical support and reusability, educators required a variety of new features related to enable greater flexibility in modifying running learning designs. Educators wanted LAMS to behave in a similar fashion to a real face-to-face class where a educator is able to modify the activities "on-the-fly" while giving a lesson.

Their rationale was that in real classroom environments, it is not uncommon for educators, while delivering a lesson, to change the activities they had planned to convey to the learners due to unforseen circumstances. For example, when a educator realizes that the learners' knowledge of the subject she is teaching is greater than she expected. In face-to-face environments, educators can opt to change the activities as they have planned to better suit their learners. This ability to adapt a lesson "on-the-fly" was a key feature that educators wanted replicated in LAMS.

Another important requirement was branching within learning designs. Educators wanted to group learners within a class based on criteria of their choice and let each group do separate sets of activities according to their criteria. In previous versions of LAMS, educators who wanted to use different pedagogical methodologies were limited to the "Optional" tool which allowed learners to choose from a set of activity tools, but this was limited to a selection from a single set (not a selection of several sequences of activities, ie: different branches). Educators wanted a richer set of branching approaches, including learner-selected branches, educator-allocated branches and automated system allocation to branches (based on prior activity tool data such as learners who have attained a certain score in a quiz activity or posted a specific number of postings in a forum).

Another requirement was the ability for learners (and also educators) to export a comprehensive record of activities conducted with LAMS to be stored outside the system (such as in an e-portfolio or Personal Learning Environment). This export output should be a static set of files that does not require any connection back to the original LAMS server (so that the record can be kept indefinitely, regardless of when a LAMS server may be shut down).

In LAMS Version 1, grouping activities allowed educators to set the number of groups into which learners would be allocated by the system in random order. Although this was helpful in certain educational scenarios, educators requested the additional feature of allowing learners to select their groups or the ability for the educator to allocate learners into groups at runtime. Educators also wanted to be able to set a number of learners per group (not just a number of groups).

Given improvements in bandwidth and storage, the need to use richer multimedia objects in online lessons is greater than at the time of initial development. Educators now expect that all learning design activity tools to support video, audio, images and other types of rich media.

Many educators who had used the LAMS Version 1 authoring had incorporated "Noticeboard" (ie, plain text) activities into which they described an "offline" activity that learners would conduct at that point in a sequence. This approach allowed a single learning design to capture a flow of both online and offline tasks. Educators asked that this potential use of LAMS (as a record of offline tasks) be formalised as an optional setting for any activity tool. To extend this feature, an "Instructions" area was provided to allow for further instructions (either to educators or learners) about how to run either online or offline activities. A file upload facility was added for both the online and offline instructions area to allow storage of related materials such as printed learner worksheets, advice sheets for educators, background articles, etc. This set of features adds a new dimension to LAMS in that it is no longer just an e-learning system, but rather it becomes a generalised lesson planning environment in which "e- delivery" of any given task is an option.

Educational research supports the concept that learner learning benefits from self-reflection as part of the learning process (eg, Laurillard, 2001). In LAMS Version 1, selected tools included writing a reflective comment in a notebook as part of the overall activity. Following feedback on the potential benefits of including this step in all tools, it was added as an optional setting for all LAMS 2 activity tools.

In support of system interoperability, LAMS 2 includes an export option for LAMS sequences using the bindings proposed in Level A of the IMS Learning Design specification.

Collaboration

Educators wanted more flexible ways to create learning designs collaboratively with other educators. This request included the ability to provide multiple shared areas for designs for different groups of educators, including a shared area for each course (rather than only one shared area for educators as in LAMS V1).

Additionally greater collaboration among educators also means sharing the workload of monitoring learners in a lesson so tutors or other teaching assistants can collaboratively assist and monitor learners along side each other and a course convenor. A course convenor can now have monitoring access of all classes, whereas tutors can be assigned only to monitor their own classes.

Usability and Interface

One of the most important requirements was the internationalisation of LAMS so that it could support languages other than English. As LAMS Version 1 only supported the English character set, LAMS 2 was built to support a wide range of character sets including double-byte characters (such as Chinese and Japanese) as well as Arabic and Hebrew (including right to left text placement).

Another important aspect of the LAMS interface is the look-and-feel. Since LAMS is integrated within other learning environments, it was important that the look-and-feel could be tailored to match that of the integrated learning environment, therefore making the user experience seamless across both systems. To support easy changes to look-and-feel, LAMS 2 uses a well-specified set of Cascading Style Sheets (CSS) throughout the system.

Educators also wanted to use rich-text editors to create rich web content for their activities. This included the ability to change font sizes and colours, and include images, flash movies, create tables, etc.

In addition to making the LAMS interface more intuitive and user friendly, accessibility requirements (W3C Level A) were implemented to assist learners with specific disabilities.

Technical improvements

Robustness, scalability and performance were the key concerns of technical teams planning to implement LAMS at educational institutions with 35,000+ learners. LAMS 2 needed to support a large number of total and concurrent users and incorporate technical features to assist this, such as database and application server clustering.

3   LAMS version 2 Architecture

Once the requirements outlined above were assessed and analysed, the planning phase started to create the specifications for LAMS 2. Given the requirements, the LAMS 2 Architecture was designed to accommodate these requirements and provide a foundation for future features and improvements.

To support simple development and installation of new activity tools, LAMS 2 implements a modular architecture where activity tools can be added on-the-fly to a LAMS 2 server. In order to provide such modularity, LAMS 2 implements a Tools Contract. As it name indicates, the Tools Contract is "contract" between LAMS Core and each tool to communicate with each other. The LAMS Core has modules for Authoring, Monitor, Administration and Learner.

The new architecture proposes a clear and defined separation between tools and core service responsibilities/functionalities.
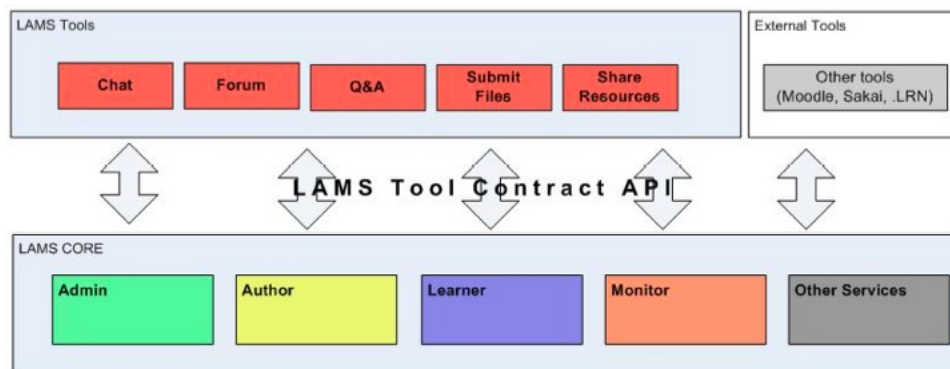
Figure 1: LAMS 2 Architecture

The LAMS 2 Architecture abstracts the interface for communication between the LAMS Core and the activity tools.

Activity tools in LAMS 2 are almost completely independent web applications that interact with LAMS Core modules and services through the Tools Contract. This contract establishes the expected behaviours and APIs that each tool needs to implement to be instantiated as a LAMS activity tool.

By following this Tool Contract, not only can a LAMS activity tool be used within the LAMS system but also external tools that implement it can become LAMS Tools.

In this way we intented to foster a community of tool developers who might already have activity tools that they would like to use in the context of LAMS and will not be required to learn all technical aspects of LAMS. By implementing the Tool Contract, they can use their tools within sequences in LAMS.

LAMS 2 Tool Contract

In formal terms, the LAMS Tool Contract is a set of expected behaviours, registered URLs and API calls that a LAMS Tool has to implement to communicate with the LAMS Core.

An activity tool interacts with the LAMS Core via URL calls and direct Java calls. It implements interfaces defined in the LAMS core, and makes use of known LAMS services supplied by the Core. Native LAMS tools are written so they use the Spring Framework (Spring Framework, 2006) to allow the LAMS Core to be able to communicate with the tool. However, external tools that might not be written in the same languages as LAMS can also be used as Native LAMS tools with an external wrapper that permits the external tool to behave in the way that the LAMS Core expects.

Each tool interacts with the following LAMS Core modules.

- Author
  Calls the tool to create/update or delete tool content. Uses the tool's authoring screens.
- Monitor
  Uses the tool's monitoring screens.
- Administration
  Uses the tool's admin screen, which may be used to configure the tool.
- Learner
  Calls the tool to copy tool content and set up tool sessions. Uses the tool's learner and export portfolio screens.
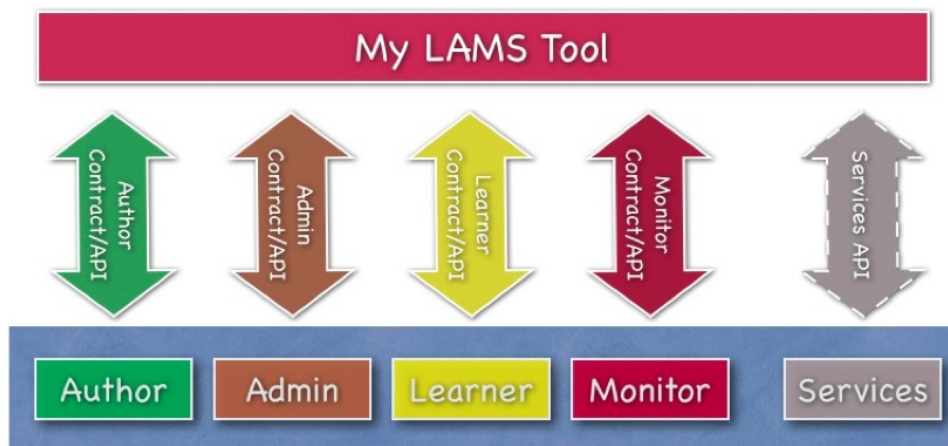

Figure 2: LAMS 2 Tool Contract

In this following section we describe in detail the LAMS 2 Tools Contract and its requirements.

Author Contract

In this section we describe the expected APIs and behaviours that an activity tool must fulfil to communicate with the LAMS Authoring module.

Authoring URL

The tool must supply an authoring module, which is called to create new content or edit existing content. This authoring module is accessed by a URL that the tool registers with the LAMS Core when it is deployed, so when an Author double clicks on the activity tool this URL will be called to author content for this activity.

Tool Icon

The tool needs to supply a tool icon so it can be displayed in the Author and Monitor interfaces.

Default content

The default content is the initial data that will be displayed when the tools are authored for the first time.

Authoring UI requirements

Authoring UI (User Interface) data consists of general activity data fields that depend on the activity purpose and the Tool specific data fields.

The LAMS authoring interface for tools have three tabs: Basic, Advanced and Instructions. Each of these tabs contains certain mandatory fields as well as the tool's specific fields according to the purpose it serves. The Basic tab displays the basic set of fields that are needed for the tool. Additionally, LAMS requires two mandatory fields (mainly for consistency purposes): Title and Instructions. The Advanced tab displays the extra fields that would be used by experienced LAMS users to set the behaviour of the tool at runtime. Finally the Instructions tab displays the "instructions" fields for educators, where the author can specify the accompanying directions or advice for educators on how to perform or deliver this particular activity. These instructions can be of two types: Online instructions and/or Offline instructions.

Preview

The tool must be able to show the specified content as if it was running in a lesson (Preview mode). During Preview, the author steps through the design as if she were a learner. In Preview, tools normally act exactly the same as they would do in the regular learner interface. The exceptions to this are tools that require interaction between users or would take a long time (e.g. a week) to complete. For example, if a tool requires two people to complete and activity before either of them could finish, then that would have to work differently in Preview, as there is only one person in preview.

Export tool content

Additionally, the tool must be able to export its tool content as part of the overall learning design export. The format of the serialization for export is XML.

Figure 3: Tool Authoring - Basic tab

Figure 4: Tool Authoring - Advanced tab
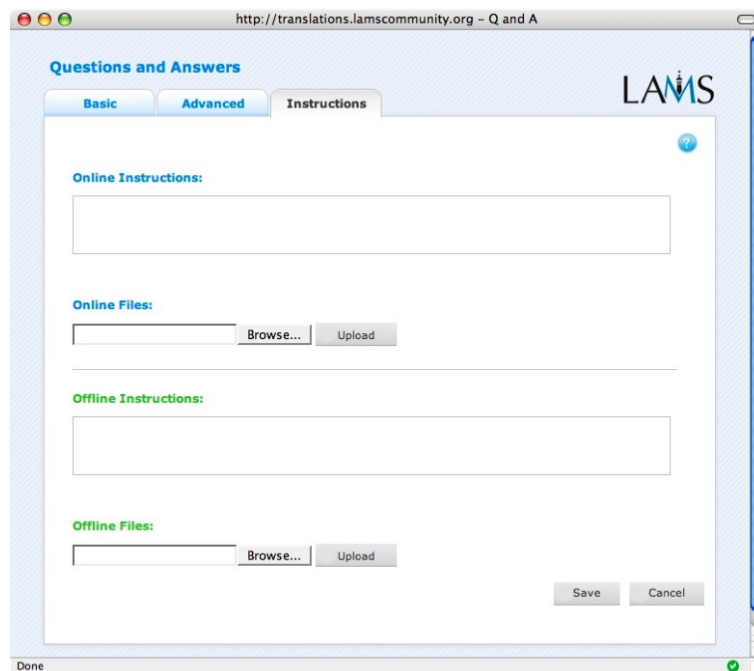
Figure 5: Tool Authoring - Instructions tab

Contextual Help

The tool should supply help information page(s) which enables the educators or learners to find useful information about authoring or working with this tool.

Data Exchange

Tools must register the type of inputs and outputs they can handle with the LAMS Core. The idea is that a tool can pass data to another tool that requires it. These are simple data types as string, text, integer, float, etc. For example, a quiz tool may pass each learner's quiz score to a later branching tool, and then the branching tool decides which branch each learner goes to according to their overall quiz score.

Monitor Contract

Learner Progress URL

The learner progress URL allows the educator to monitor the contribution of a particular learner to a particular activity.

Monitor URL

The screen provided by the Monitor URL is the main monitoring screen for the tool. As with the authoring screen, there are a series of tabs which allow the educator to select from various functions.

The Monitoring screen has the following tabs:

- Summary: displays a summary of all the learners' responses and allows learner entries to be modified or hidden.
- Instructions: displays the online and offline instructions, entered during authoring to provide directions for tutors or teaching assistants on how to run or use this activity with learners.
- Edit Activity: allows a educator to set or modify the tool content.
- Statistics: displays usage statistics for a tool e.g. the number of users completed, the percentage of correct answers, etc.

Note that a tool may include other tabs if it is required to display anything else that does not fit on one of the standard four tabs.
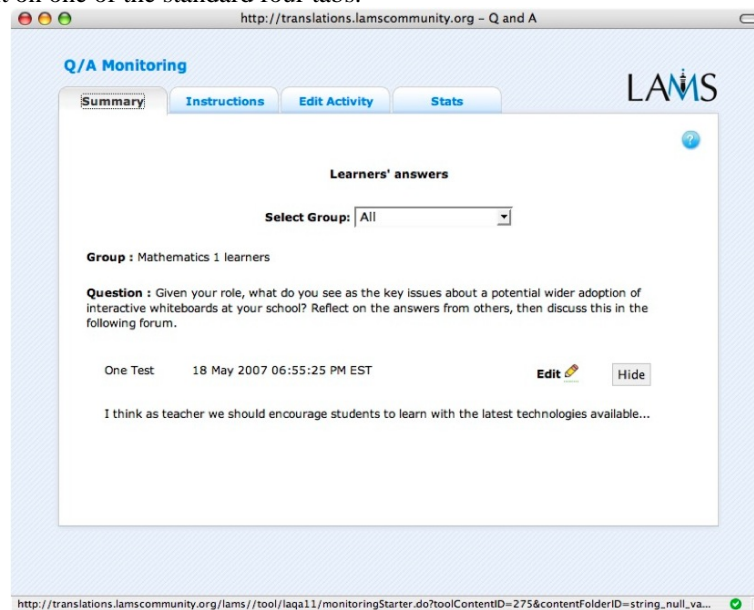
Figure 6: Tool Monitor - Summary tab

Export Portfolio URL

This screen allows the user to export in plain HTML the contribution of one or all participating learners. The concept is to record what the learner has seen on her screen. The portfolio may be for an individual learner, or may be for the whole class (this is accessible only by the educator).

Modifying Tool Content

At runtime, educators might need to change the content of an activity. Therefore the tools must provide an interface to change its content while the activity is running.

Learner Contract

Learner URL

This is the URL that "plays" the content to learners and is responsible for tracking and recording the progress of the user. When the user has completed the activity tool then the tool notifies the progress engine.
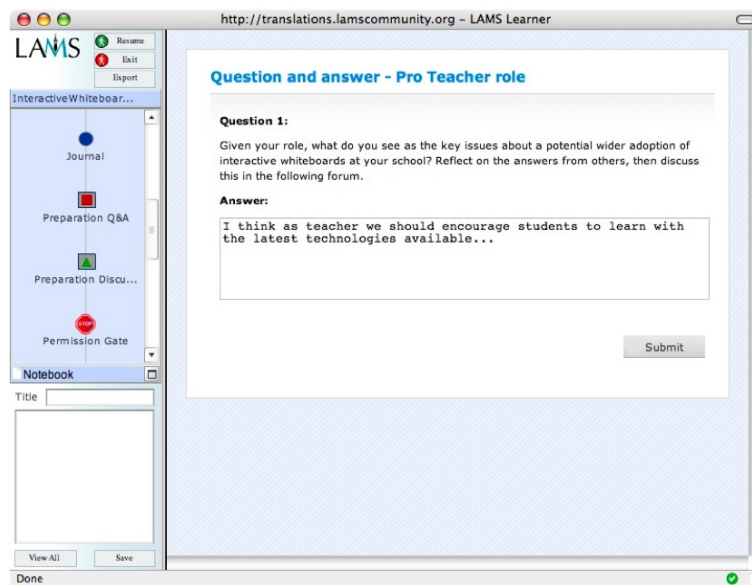
Figure 7: Tool Learner's page

Export Portfolio URL

This screen allows the learner to export in plain HTML the contributions of all learners in this learner's groups – that is, a record of each screen seen by this learner during the sequence of activities.

Admin Contract

Administration URL

All tools define some technical metadata on installation. Tools must also supply a URL, which may be used for updating this information, along with any tool specific configuration details.

The administration URL should also allow access to any administrative tasks e.g. reviewing a tool log, runtime stop/start of the chat server, or a monitor method which shows which Chat rooms, are active.

External Tool Wrappers

LAMS Version 1 has been integrated with a number of open source and proprietary learning management systems. After we released these integrations, educators have pointed out that they would like to use the LAMS tools together with the tools from their own learning management system within a LAMS learning design.

Thus in LAMS 2, we have conceptualised external tool wrappers for different learning management systems that could allow their tools to be "LAMS enabled".

Figure 8: LAMS External Tool Wrapper

These tool wrappers allow the external tools to comply with the LAMS Tools Contract as well as handling authentication and authorization. By doing so, these external tools can be included in LAMS sequences. Figure 8 and 9 show an example of how a tool wrapper for a Forum tool from Moodle would be able to work within LAMS.
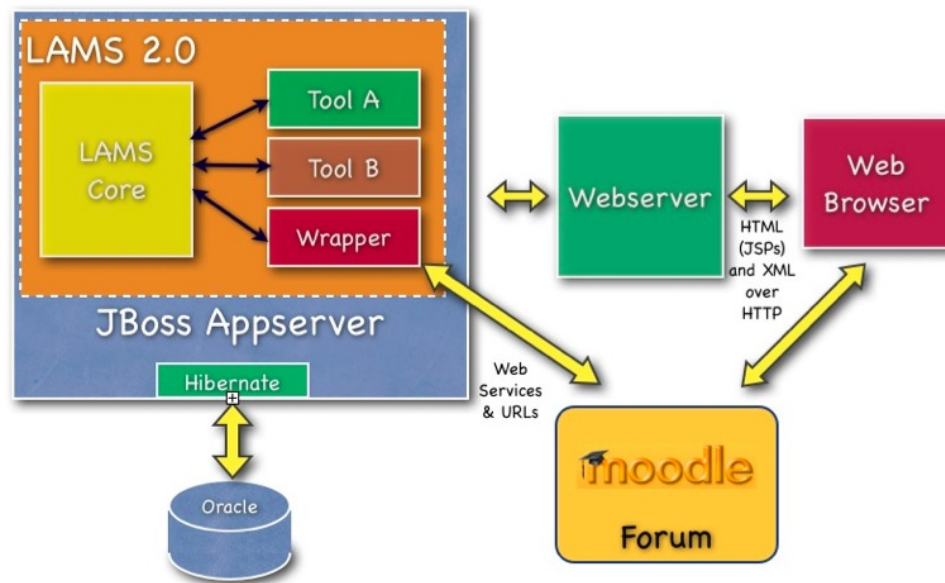
Figure 9: Moodle External Tool Wrapper

4   Conclusion

The design of LAMS 2 was based on extensive user feedback as well as the outcomes of formal evaluations of LAMS version 1 implementations. New and improved features were incorporated into LAMS 2 to: improve pedagogical support and re-use; enhance collaboration among educators (as both authors and monitors); improve the user interface and overall user experience; and to provide greater robustness, scalability and reliability. Key features supported by LAMS 2 include: edit-on-the-fly, branching, rich multimedia; "offline" activity information; optional reflections for all tools; a wider range of grouping options; "portfolio export" and support for languages other than English.

One of the key architectural improvements of LAMS 2 was the introduction of the "LAMS Tools Contract" – a set of expected behaviours about how an activity tool interacts with the LAMS Core "workflow engine" in terms of four areas: Author, Monitor, Learner and Administration. The Tools Contract fosters easier creation and integration of new activity tools into the LAMS framework, as well as integration of external tools via a "tools wrapper". The LAMS Tools Contract also provides a set of innovative functionalities that could inform the next generation of interfaces between e-learning platforms and activity tools.

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Some Findings from the Evaluation of the Collage Authoring Tool

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Abstract: The design process implemented in Collage authoring tool enables the creation of collaborative IMS Learning Design (IMS LD) compliant Units of Learning (UoLs) by starting from templates based on patterns. In this paper, we present some findings from the evaluation of Collage in a case study that includes several workshops devoted mainly to the ultimate target audience: teachers with interest in applying Computer-Supported Collaborative Learning (CSCL) designs in their educational practice but who are not familiar with IMS LD. The findings are organised around two main topics: the pattern-based design process and the use of Collage.

Keywords: IMS LD, CSCL, scripts, authoring tool, patterns, templates, case study

1 Introduction

Collage is an authoring tool which implements a design process that facilitates the participation of teachers in the creation of potentially effective CSCL scripts (designs based on generalizations of documented good practices) represented with IMS LD (Hernández-Leo et al., 2006). With this purpose, Collage provides teachers with a set of graphical IMS LD (Koper & Olivier, 2004) templates that can be assembled and refined according to the needs of each educational situation (Hernández-Leo, Harrer, Dodero, Asensio-Pérez, & Burgos, 2006). The templates are based on patterns (called Collaborative Learning Flow Patterns, CLFP) that formulate the core of common solutions when designing flows of (collaborative) learning activities. Therefore, Collage aims at fostering the reuse of broadly accepted collaborative learning structures in such a way that they can be used in many different situations, with different content and disciplines; thus adopting the pattern-based design approach already exploited in Architecture (Alexander et al., 1977), Software Engineering (Gamma, Helm, Johnson, & Vlissides, 1995) and also Educational Design (Goodyear, 2005).

In this paper, we describe part of the evaluation that we have completed to illuminate the value of Collage and its associated design process. Particularly, we focus on a case

study (Zelkowitz & Wallace, 1998; Stake, 1995) that involves four workshops in which different audiences (mainly the target users) create UoLs based on CLFPs using Collage.

Therefore, the paper is organised as follows. Section 2 first describes the case study. Then, Section 3 presents the evaluation results. Finally, Section 4 concludes this paper indicating further work accomplished to complement this evaluation.

2   Description of the case study

The case study is designed according to the guidelines proposed by Stake (1995). Table 1 summarizes the four experiences (workshops) considered in the case study. The different experiences form a single case study since they all analyze the same functioning, "creating collaborative LDs using Collage", and share the same conceptual structure. This conceptual structure includes an issue, representing the general research question, the topics on which the study is focused and the particularization of the topics into more concrete information questions that guides the data analysis (Stake, 1995). In this case, the issue is: **does the design process implemented in Collage facilitate the reuse of CLFPs in the creation of particularized IMS LD-represented CSCL scripts?** The topics discussed in this paper are "the pattern-based design process", and "the use of Collage".

Table 1.   Summary of the experiences involved in the case study

Name of the workshop (chronological order)	Interviewees (type of audience) (number of persons that complete the questionnaires)	Deployment	Data sources (and labels used in the text to quote them)
GSIC/EMIC (May 2005)	Five members of the GSIC/EMIC research group: CSCL practitioners without deep knowledge on IMS LD	- Free deployment (with assistants)	- Final questionnaire [GSIC/EMIC] - Created scripts
UNFOLD (October 2005)	*Seven (official and invited) members of the UNFOLD project: educational technologists (some of them experts on IMS LD)*	-Familiarization (presentation), -guided creation of a CSCL script	- Final questionnaire [UNFOLD]
UVA (March 2006)	Five teachers of the University of Valladolid (Spain) with interest in technology and collaborative learning and without knowledge on IMS LD	-Familiarization (presentation), -guided creation of a CSCL script - free deployment (optional, with assistants)	- Initial (before familiarization) [UVA-quest-initial] and final questionnaire [UVA-quest-final] - Observations [UVA-observers] - Discussion group

			[UVA-discussion]
UCA (March 2006)	14 teachers of the University of Cádiz (Spain) that use a virtual campus without deep knowledge on IMS LD	- (Previous sessions about LD) -familiarization (presentation), -guided creation of a CSCL script, - free deployment (optional)	- Initial (before familiarization) [UCA-quest-initial] and final questionnaire [UCA-quest-final] - Discussion group [UCA-discussion]

The most relevant experiences are **UVA** and **UCA** since the involved interviewees (participants) are the target audience, teachers (from the University of Valladolid and from the University of Cádiz, both in Spain) with interest in applying collaborative learning and educational technology but without deep knowledge on IMS LD. Both experiences consist of four-hour workshops (or "hands-on" sessions) in which, after a presentation of Collage, the participants create proposed CSCL scripts (UoLs) following the design process implemented in Collage. The case study is enriched with two embedded mini-cases (**UNFOLD** and **GSIC/EMIC**) accomplished as (shorter) workshops in which educational technologists and researchers (members of the UNFOLD project) and CSCL practitioners (members of the GSIC/EMIC group) participate.

For the collection of the evaluation data, we employ an adaptation of a mixed evaluation method (Martínez-Monés, 2003) combining quantitative and qualitative data gathering techniques. Quantitative data are considered useful for showing trends. The emphasis is on the qualitative results, which are used to confirm or reject those trends as well as to understand them and identify emergent features in the particular representative situation (Denzin & Lincoln, 2005). The data sources include: questionnaires, web-based questionnaires completed before and after the experiences; observations, observers note down interactions, attitudes and incidents that occurred during the workshops and elaborate a report; and discussion groups, a debate with the participants after the workshops is recorded and transcribed. Using a qualitative analysis tool (SQR, 1997), the full amount of data is aggregated and comparatively analyzed (triangulated) (Guba, 1981) according to a set of categories that derived from the information questions associated with the topics of study. These information questions guide the presentation of the evaluation results.

3   Some evaluation results

Table 2 collects the evaluation results referring to the information questions that derived from two of the topics under study ("the pattern-based design process" and "the use of Collage") together with the data source that support them. Due to space restrictions, this section disscuses only some of these results illustrating how qualitative and quantitave data found the conclusions.

We claim as our working hypothesis that our approach facilitates the reuse of CLFPs when teachers create their own UoLs instead of starting from scratch. The results related to the two first information questions (Table 2) indicate some evidence of this. For example, according to the interviewees the "selection of patterns" phase in Collage is critical and promotes the understanding of the patterns. (Note that the conclusions of the analysis are underlined.) As one of them mentions "… *a minimum formation on patterns*

is necessary, for which Collage is helpful [UVA-discussion]." In fact, many participants provide arguments that agree with this declaration of a UCA teacher "*Collage systematizes the selection of patterns* [UCA-quest-final]." Another conclusion is that the possibility of <u>combining patterns provides design flexibility</u>. The utility of the combination of CLFPs is rated (in the range of 1 (it is not useful) to 5 (it is very useful)) with an average of 4.21 by the UCA participants and 4.20 by the UVA teachers. As one of them affirms "*I think that the combination of patterns allows a better adaptation of the activity to the problems and methods that we want to develop, making the activity more complete* [UCA-quest-final]." This result is also shared by the UNFOLD interviewees; "*… it would be nice if other patterns could be added! However, as patterns can be combined, these already offer quite a lot of flexibility* [UNFOLD]."

Table 2.   Some conclusions offered by the evaluation of the Collage workshops

Information questions	Evaluation results	Main support data source
Is the selection of the CLFP-based IMS LD templates and their representation useful?	- The selection phase is critical and promotes the understanding of the patterns	[UCA-quest-final], [UVA-quest-final], [GSIC/EMIC], [UCA-discussion], [UVA-discussion]
	- The CLFPs are significant but there are other well-known strategies (e.g., for assessment)	[UCA-quest-final], [UVA-quest-final], [GSIC/EMIC]
	- The interviewees' ideas of the CLFPs coincide with what is presented in Collage	[UCA-quest-final], [UVA-quest-final], [GSIC/EMIC], [UVA-discussion]
Does it achieve a satisfactory trade-off between the reuse of CLFPs and the creation of scripts contextualized according to the situational needs?	- The combination of patterns provides design flexibility	[UVA-observers], [UNFOLD], [UCA-quest-final], [UVA-quest-final], [UVA-discussion]
	- Pattern based templates are probably more useful in the process of customizing a new situation than ready-to-run exemplars, but complete examples are also useful	[UCA-discussion], [UVA-discussion]
	- Satisfactory trade-off between flexibility, keeping the essence captured in the CLFPs, hiding IMS LD-specific technological details and providing a clear (but limited) set of design options	[UCA-quest-final], [UVA-quest-final], [UVA-discussion]
Can the teachers use successfully Collage?	- Most of the participants find Collage user-friendly and intuitive and are able to create partially completed examples during the workshops	[UCA-quest-final], [UVA-quest-final], [UNFOLD], [UVA-discussion]
	- Very few problems appear but the participants indicate the importance of applying the designs in real situations	[UCA-quest-final], [UVA-quest-final], [GSIC/EMIC]
	- Collage is easier to use, specific to collaborative learning and it is the first IMS LD editor providing pattern-based templates	[UNFOLD]
How can Collage be improved?	- Incorporating more CLFPs and other types of patterns (also non-pattern based elements), which would provide more flexible design options	[UCA-quest-final], [UVA-quest-final], [UNFOLD], [GSIC/EMIC], [UVA-discussion]
	- Level B and C of IMS LD	[UNFOLD]
	- "Preliminary view" of the LD	[UVA-quest-final], [UVA-discussion]

- The integration of Collage with instantiation and delivery systems should support flexibility	[UCA-quest-final], [UVA-quest-final], [UCA-discussion], [UVA-discussion]

The results associated with the last two information questions (Table 2) indicate that Collage is user-friendly and intuitive and specific to collaborative learning. It can be enhanced with further design options and by its integration with complementary tools. Some statements supporting these conclusions are: "*I am satisfactorily astonished by the user-friendliness of the tool; I thought that it was going to be more difficult...* [UCA-quest-final]", "*I was able to create an IMS LD reflecting a previous CL experience without deep knowledge on IMS LD* [GSIC/EMIC]", "*makes Reload much easier to use for specific purposes* [UNFOLD]."

4   Conclusion and further work

The case study presented in this paper focuses on the evaluation completed in Collage workshops (two experiences with the target audience and two mini-cases). The results are positive with respect to the pattern-based design process and the use of Collage authoring tool but they also provide pointers for several enhancements and new research efforts (such as incorporating assessment patterns or providing support to different teaching needs related to diverse subjects or type of students). This evaluation is complemented with two different case studies. One of them involves an experience in an authentic learning situation in which students complete a UoL created using Collage (Hernández-Leo et al., in press). The other case study entails the participation in a workshop (Vignollet, David, Ferraris, Martel, & Lejeune, 2006) where we use our approach to create a UoL representing an scenario proposed by a third party and compare the result with related work.

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Experiences with GRAIL: Learning Design support in .LRN

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Abstract: The IMS-LD specification allows the transcription of almost any pedagogical model in a "Unit of Learning" (UoL), which is a package where contents and methodology are combined together in order to be deployed in a compliant software. The efforts to adopt these specification can be divided into two categories: tools supporting the design phase, and run-time environments capable of interpreting the resulting UoLs. In this paper the Learning Design run-time environment GRAIL is presented. The system is embedded in .LRN an open-source industrial strength learning management system. Two real experiences with this environment are shown. The first one uses a set of collaborative patters for learning, whereas the second captures the structure of a convencional engineering course.

Keywords: Learning Design, run-time environment, LMS, real experiences

1   Introduction

Since its initial version was released, Learning Design has been following a sustained adoption rate. From the initial prototypes to current state of the art supporting tools, the advance has been significant. Still, when trying to use Learning Design with a convencional Learning Management System (henceforth LMS) in conventional courses, difficulties appear.

On one hand, LMSs are increasingly complex platforms offering a richer set of resources and functionality to users. Learning Design run time environments or RTEs need to capitalize in this functionality and take advantage of it to offer a tight integration with all their services.

On the other hand, when capturing conventional courses with Learning Design, there could be some special issues and circumstances, that although not paramount for Learning Design, they need to be easily solved in order to facilitate its adoption.

The current document presents GRAIL, the run time environment implemented as part of the .LRN Learning Management System. It provides support to all three levels of the specification as well as a tight integration with an already established and comprehensive set of resources.

Additionally, two experiences of its use in real scenarios are described. The first one is oriented toward capturing a collaborative distant learning scenario in which a rich set of additional tools are required. The second experience tries to capture a conventional course with a highly parallel structure.

2 Learning Design RTE integration in .LRN

Current tools providing a run time environment interface such as CopperCore [1] or integrated environments such as SLeD [2] allow UoLs to be successfully deployed and used in real teaching situations. However, tools not fully integrated in a comprehensive learning platform usually require an extra effort on administration and synchronization issues with external platforms.

A tight integration of a Learning Design RTE in a conventional LMS has plenty of benefits that address, to a large extent, this kind of problems. User management is more straightforward. The administrator deploys a UoL for the users that are already singed in the platform. Also, when properly integrated, service deployment is a one step task. Once deployed, with the proper RTE, any UoL may benefit from them. With a set of services tightly integrated in the same platform, data exchange among them through a UoL is easily achieved. And finally, users do not perceive using UoLs as a separated task, but as yet another serviced offered by the platform.

This is precisely the aim of GRAIL. It is a Learning Design run time environment fully integrated within the .LRN learning environment. It follows a brief description these tools.

The .LRN Learning Management System

.LRN [3] is an enterprise-class open source platform for supporting e-learning and digital communities. The tool was originally developed at the Massachusetts Institute of Technology as a virtual learning environment, and then evolved into a comprehensive platform including not only e-learning support but also generic web resources.

The platform is based in the Open Architecture Community System [4] (henceforth OACS), a toolkit for building scalable, communication-oriented web communities and applications. The toolkit structure uses AOLServer as its web server [5] and is highly modular. .LRN is a higher level layer which adds support for working with generic user communities. The already existing modules in OACS for community based contexts, proved an effective underpinning to turn .LRN into a powerful learning management system.

GRAIL: Learning Design support in .LRN

Fully integrated with .LRN, the GRAIL tool (GRAdient Rte for Imsld at .LRN) [6] provides support for the entire Learning Design specification in the platform. It takes advantage of the community-based approach of the system, allowing teaching staff to deploy UoLs in the context of an existing class or generic student community.

When deploying a UoL, the first step is to instantiate it (to create a run) and to assign users to the newly create instance. This stage is implemented starting with all members of

the community where the UoL has been instantiated as members of the course. Then, the community administrator has the capability to associate users to defined roles through a simple user interface illustrated in Figure 1.

Figure 1. Role assignment interface for UoL management

All three levels of the specification are supported by the tool. The first one, level A, contains the core engine of the sequencing rules. It also deals with dynamic service instantiation, that is, learning objects that cannot be completely defined at design time because they require run time interaction with the course members. Communication based services (sendmail and conference) are supported in GRAIL by leveraging in the already existing .LRN capabilities.

Level B properties and conditions allow activities to be conditionally sequenced. Property usage also implies support for managing global elements inside *imsldcontent* resources. This content is processed at the server-side, so the client browser receives the final XHTML document instead of the internal content. As for level C, notifications are allowed to appear with certain events such as activity terminations and they may change visibility attributes of a given activity through properties. As an additional feature, .LRN has a comprehensive and global notification mechanism where the user may choose which events must be notified by e-mail that its frequency (instantly, hourly or daily).

In addition to the specification, GRAIL provides some utilities to facilitate UoL deployment. One of them is a comprehensive monitor tool. It is monitor service created by default where all properties in a UoL can be viewed and/or modified. The platform automatically creates one instance of this service for each of the runs created in the platform. The access to this monitor is restricted to the administrator of the course. Experience has shown this feature very effective to track and debug errors in UoLs.

Learning Design is not the only specification supported by .LRN. Taking advantage of this fact, GRAILhas been implemented to provide information exchange with other modules providing run time environments for SCORM (content packaging) and QTI. SCORM or QTI resources may be included in the given UoL. When part of a given UoL, both SCORM and QTI resources are treated as regular resources.

Additionally to this support, and derived from the integration with .LRN, whenever a UoL is deployed, all its resources are transferred into a file storage area which is visible to community members both through web and WebDAV interfaces. This functionality, although far from the desired authoring capabilities, allows for quick and simple content modifications.

3 User experiences with GRAIL

The advantages of having the Learning Design player tightly integrated with a LMS are specially relevant at deploy and run time. In order to test the true support of the specification, several practical experiences based on real scenarios were designed. Two of them are described in this document.

The first one was based on a collaborative learning approach among geographically dispersed members. The main objective was to test the capability of the platform when combined with external resources as well as the expressive power of the specification. The second one was to map an already existing engineering course with a significant number of parallel activities into the Learning Design specification.

Collaborative and Synchronous Learning

Collaborative learning approaches has been widely studied and used. During most of the time, and specially during synchronous sessions, students are required to work together. However, when combined with a distance learning scenario, the deployment is significantly more complex. The objective of this experience was to deploy a UoL combining both distance and synchronous collaborative learning.

The designed learning flow required the study of a set of documents on a previously chosen topic. This flow had the following structure:

1. Students are divided into groups. Each group is assigned a different document, which they have to read individually. Readers must produce a set of comments about the document.
2. Each student analyzes the comments produced by members of other groups.
3. The previous activity is repeated with comments produced by the students in the same group.
4. All the students have a meeting in which they discuss all issues related to the read documents.

The main problem faced when translating this flow to Learning Design was related to student groups (see Figure 2). Each role can be divided in groups, but there is no way to specify how these groups interact with each other in the same role or in a different one. For example, members of group A must read comments from members of group B, being all of them members of the same role.
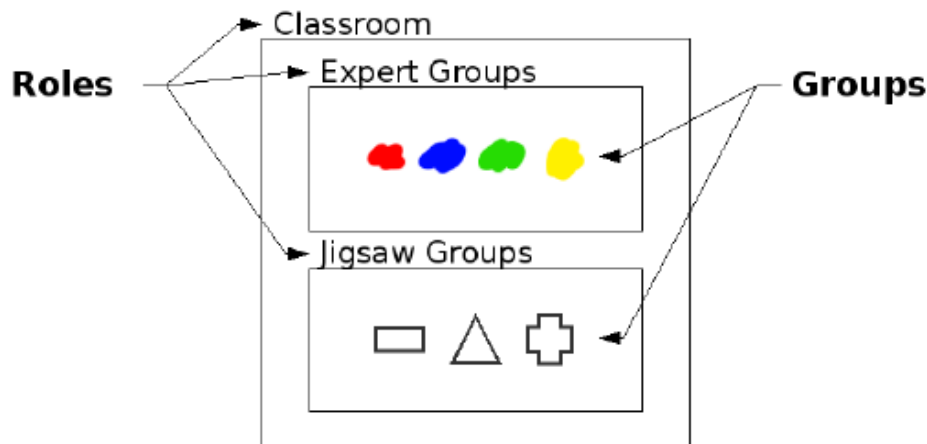
Figure 2. Roles and groups in the collaborative UoL.

To solve this shortcoming, properties were used to encode grouping. Even though properties were not conceived with this task in mind, the problem could be solved dynamically. Each student had two properties, one for each low level role, whose value refers to the group in which the student participates. The combination of these properties with the use of *imsldcontent* resources resulted on dynamic content which solves the problem of document assignment.

Another issue which was not satisfactory solved by Learning Design was the use of external tools. When supporting distant collaboration a heterogeneous set of tools (shared drawing board, VoIP clients, shared Mindmaps, etc.) are usually required. Although a UoL may refer to these tools through URIs, it does not solve typical integration problems. For example, external tools are not easy to track, and extra administrative tasks are required for them to work properly within the UoL.

Overall, the results derived from the experiment emphasize the importance of an integrated environment that must facilitate information exchange by several means. An LMS is the proper vehicle where this kind of information can flow, allowing course members to be always in the same environment.

A Conventional Course captured with Learning Design

Many documents about Learning Design found in the literature [7, 8] claim that the specification is able to capture almost any existing pedagogical model. The goal of the second experience was to map an already existing course into Learning Design without loosing any of the course features. The starting point is a regular course within a regular degree in a higher educational institution. For more information see [9].

The main characteristic of the course being translated is it overlapping structure between sessions. Laboratory sessions are schedule almost on a weekly basis, but in parallel to them, theory lectures are also taking place. Solving the exercises in a laboratory is done while the theoretical concepts for the next unit are being covered. Both lab and theory material is distributed through a web interface.

This overlapping structure translates into a complete absence of what could be called "synchronization points" in the course where no progress is allowed until all students and

teachers reached it. Such structure does not map trivially into the theater metaphor. Activities from an act do not start until the previous act has been completely finished, thus synchronizing at that point all users. The strategy followed to solve this problem was to use activity structures. These structures allow for content to be delivered with a combination of parallel and sequential steps but synchronization points were not required.

Even though the use of structures provided a feasible context for the course, there were some problems when trying to capture the action of finishing an older activity the deadline of which was overdue. The solution was to provide the teaching staff with a property to control when an activity is officially finished. By using the monitor service described in the previous section, the teaching staff had flexibility to control the state of the activities encoded as *imsldcontent* type resources.

Even though the course structure was finally captured, the required level of proficiency with the specification was higher than desirable.

4 Conclusions and Future Work

The use of GRAIL, a run time environment tightly integrated inside the open source learning management system .LRN has been described. The advantage of this tight coupling are that the run-time environment may leverage the functionality already present in the platform.

Two experiences of using GRAIL were described. The first one uses Learning Design to capture a complex distant collaborative environment integrating the use of some required external tools. The second experience showed a conventional engineering course that required a level of parallelism higher than usual. This flow was captured with Learning Design but it required using a non intuitive combination of activity structures and properties.

As a conclusion, although GRAIL supports all three levels of the specification, the experiences uncovered several aspects suitable to be improved. A monitoring application is automatically deployed for each UoL allowing administrative staff to have a comprehensive control over all the properties included in a UoL. When combined with the functionality already present in .LRN, several tasks, such as simple changes in already published resources, are greatly simplified. The improvements in this functionality would allow the teaching staff to change more aspects of the UoL such as conditions, resources in the environments, etc.

A second direction for improvement is in the area of full integration of generic services. This integration can be achieved if properties values can be given to a service and additional values retrieved and included as regular properties in a UoL. An examplewould be the ability to sequence content depending on the result of a test.

Although this document covered solely the run-time aspect, a significant effort still remains to be done in the authoring process. Current authoring platforms still require a level of expertise higher than desirable thus ruling this technology too complex to a significant part of its potential users. Also a tight integration of the three environments, authoring, run-time environment and learning management system, still needs to be properly solved.

Acknowledgments

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PILOTS, REPOSITORIES AND METADATA

Pilot evaluation in TENCompetence: a theory-driven model

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Abstract: This paper describes a theory-driven evaluation model that is used in evaluating four pilots in which an infrastructure for lifelong competence development, which is currently being developed, is validated. The model makes visible the separate implementation steps that connect the envisaged infrastructure at the very beginning to the actual learning outcomes at the end. The model shows how each implementation step can lead to differences that may influence the ultimate outcomes. We first show the characteristics of the model, and how they are derived from existing evaluation literature. Secondly, we show how the model is used in the several stages of evaluation, including its use to test the program theory.

Keywords: lifelong learning, competence development, evaluation model, multisite evaluation

1 Introduction

This paper is about the design of the pilot evaluation in the TENCompetence project. The TENCompetence project is a four-year project in the European Commission's 6th Framework Programme, priority IST/Technology Enhanced Learning. The aim of the project is to design a technical and organizational infrastructure for lifelong competence development. The project develops new innovative pedagogical approaches, assessment models and organisational models, and it creates a technical and organizational infrastructure which integrates existing isolated models and tools for competence development into a common framework.

The TENCompetence infrastructure will be validated in four different pilots, representing the variety of contexts in which lifelong competence development takes place. One pilot in Spain aims at lifelong learners in the film industry who have to learn to master digital cinema techniques. One pilot in Bulgaria aims at teachers who have to update their skills in using ICT in teaching. A third pilot in several African countries aims at students in water management, and a fourth pilot in Belgium aims at establishing an infrastructure for Antwerp as a lifelong learning city. The evaluation of these pilots is a complex undertaking, caused by expected large differences among the pilot sites. Learning objectives will be different, the intended audience and thus the learners

involved will be different, and as the system is under development, the system implementation and the way in which the system is used, will be different.

To get and hold a firm grip on such a complex evaluation, a solid evaluation design is an essential requirement. In this paper we describe a model that was developed for underpinning the evaluation design, and we explain how the model is and will be used in designing the evaluation processes.

2   The model
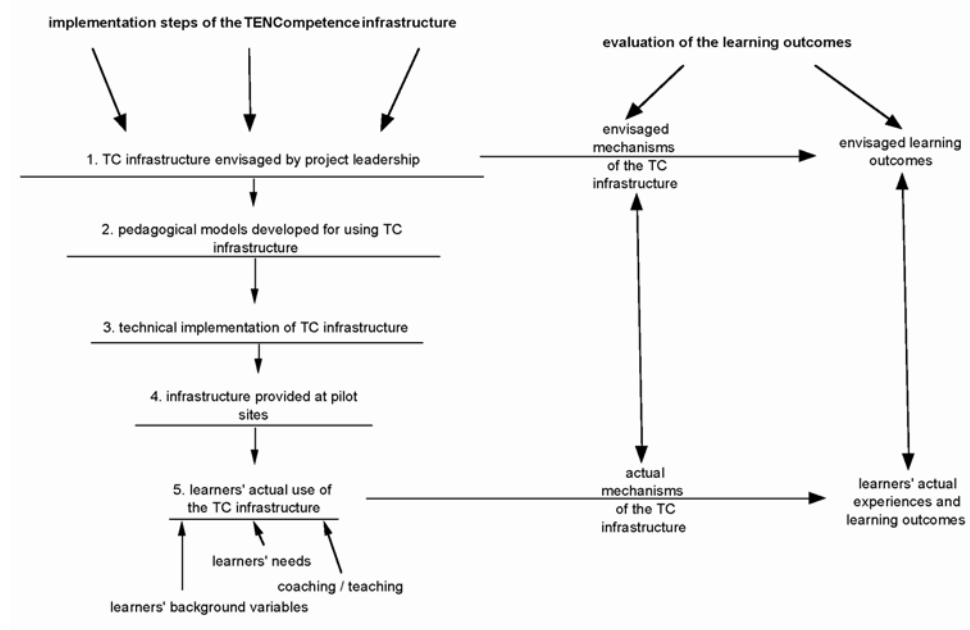
Figure 1 The pilot evaluation model, showing the implementation steps and evaluation of the
          learning outcomes

Our model of pilot evaluation has three pillars: (1) a series of implementation steps, (2) a distinction between envisaged and actual mechanisms and outcomes and (3) a recognition of various sources of differences.

Figure 1 presents our model of the pilot evaluation. The left part presents the implementation steps of the TENCompetence infrastructure, starting with the infrastructure as envisaged by the project leadership at the beginning of the project (step 1), and gradually moving downwards towards the ultimate use that learners make of the infrastructure (step 5). In between, a hierarchy of steps is shown that represent the progressing steps in implementing the infrastructure. In research terms, these steps represent a hierarchy of variables that possibly influence the outcomes (Costner, 1989). The right part represents the step from the use of the infrastructure towards the outcomes of that use. The components of the model will be discussed in more detail below.

With respect to our third pillar, the following important sources of differences were identified:

- The pedagogical models for using the envisaged TENCompetence infrastructure will only partially be implemented in the technical infrastructure (the software).

- The functionalities of the software will differ between releases.

- The pilots offered at the various pilot sites will only make use of part of the available technical infrastructure.

- Among pilots, there will be differences in which part of the available technical infrastructure individual pilots will use, accompanied by differences in the content of the pilots, the target audience, duration etcetera.

- Individual learners will use only part of the technical infrastructure offered by the pilot in which they participate.

- Among learners, there will be differences in which parts of the available technical infrastructures will be used by individual learners, accompanied by other differences such as background, learner needs and differences in coaching.

The model is intended to guide the pilot evaluation in two ways. Firstly, it enables the description of the pilot results at different levels, such as 'how was the infrastructure implemented', 'how was it used', 'what were the results of use'. Secondly, by comparing the envisaged use and learning outcomes to the actual use and outcomes, the model can be used in testing the program theory, i.e. the hypothesized relations between infrastructure and outcomes. Thirdly, by incorporating the many sources of difference that can influence the outcome, a detailed investigation of the outcomes is enabled.

3   Model components

This section describes the three pillars of the model in more detail and links these to the literature. We start with the implementation steps. The model is a form of implementation evaluation (Patton, 1997), in which the chain of steps between vision and implementation is described (King, Morris, & Fitz-Gibbon, 1987; Williams & Elmore, 1976). The following chain is set up: in step one, an infrastructure is envisioned by the project leadership. This vision is translated into a pedagogical model for lifelong competence development in step two. In step three, the pedagogical model is materialized into the TC technical infrastructure, the piece of software that is built by the software developers. In step four, providers of competence development programs in the pilots make a selection out of the available technology and models that fit the needs of their intended audience. In step five, learners actually use the technical infrastructure that has been made available to them by the pilot providers.

Our evaluation model focuses on differences, as listed above. These differences include the discrepancies that arise when one moves down the implementation steps in Figure 1. As becomes clear from the right part of the model, it focuses on discrepancies between the ideals and the actual outcomes that result from the implementation process (Provus, 1971). For example, according to the TENCompetence pedagogy for lifelong

competence development, learners should be enabled to select their own competence development program. This implies that the route along which learners reach specific learning objectives may well be different for different learners. In the technical infrastructure of step three, this possibility of choosing one's own competence development program has been implemented. However, in step four, it is conceivable that a provider offers 'one size fits all' competence development programs, which do not allow learners any freedom. In that case there is a discrepancy between the available infrastructure in step three and the infrastructure offered by providers in step four. Discrepancies may arise at other places, for example between the infrastructure offered by providers in step four and the use that learners in step five make of this infrastructure. If the providers enable sharing of resources between learners, but learners do not use that functionality, then there is a discrepancy between these two stages.

The discrepancies in the implementation process are not the only differences that are included in the model. For example, there are differences between pilot sites. In fact, the discrepancies mentioned above are a special type of differences. These are differences that result from concepts in a specific step not being implemented in the next steps. But there are also more general differences between pilot sites. For example, the model includes differences between learners. Learners may differ in their background and learning needs. And when compared on the content levels, the resources used in separate pilots can be very different. More generally, all variables that are expected to influence the outcomes, are included in the model, rather than 'controlled' by randomization (Chen & Rossi, 1987; Costner, 1989).

As a third pillar, the model focuses on the program theory and on testing this theory. The envisaged use of the infrastructure and the envisaged outcomes are part of the model (see the right upper part). Also included are the envisaged mechanisms that relate the use of the infrastructure to the outcomes. This is called the program theory, and the corresponding evaluation is called theory-driven evaluation (Chen & Rossi, 1987; Patton, 1997). These are the ideas of its inventors on how they think the TENCompetence infrastructure works. Part of this theory are arguments such as 'if learners can determine their own learning path, the units of learning chosen will better match their need and if chosen units of learning better match their needs, learners will learn more' or 'if prior learning is assessed, then units of learning can be chosen that better match the learners proficiency level; if chosen units of learning better match the learners' proficiency level, learners will learn more'.

The outcomes, mentioned under point four, play a central role in testing the theory. An important part of the evaluation is testing whether the program theory holds in the pilots. If, for example, at a particular pilot site, learners cannot choose their own learning path, but yet do not learn less than learners who can choose their own learning path, then obviously, there is a problem with the program theory of the last paragraph.

In testing the program theory, our model goes much further than establishing whether the infrastructure has been set up. The model focuses on outcomes, rather than services delivered. The learning outcomes are explicitly included in the evaluation (Patton, 1997). The model also includes the needs of the learners (Scriven, 1993). The inclusion of learner needs fulfils two functions: firstly, differences in learner needs between learners and between the pilots are measured and are considered to be part of the relevant differences in pilot implementation, which may account for differences in outcomes. Secondly, learner needs are used in measuring the outcomes. Part of the outcomes

includes the extent to which the learning experience using the infrastructure meets the learner's needs.

It is important to recognize that our choice for this specific model is a deliberate choice from several alternatives, and it stems from requirements within the TENCompetence project. Basically, the model follows from the fact that within the TENCompetence project, intended outcomes had been developed. These include:

- Learners pro-actively share knowledge and learning resources

- Learners create, store, use and exchange knowledge resources, learning activities, units of learning, competence development programmes and networks for lifelong competence development.

- Learners establish decentralized, self-organized and empowered competence management

- Learners realize competence development.

- Learners find solutions to learning problems

This makes it inevitable to investigate whether these learning outcomes have been achieved, rather than just measuring effects of working with the TENCompetence infrastructure (pillar 2). Furthermore, it will be inevitable that in the implementation from vision to actual use by learners, not everything in the vision will be implemented and used, and this makes it necessary to measure the differences (pillar 1). Finally, as the actual implementation and use of the TENCompetence infrastructure at individual pilot sites and by individual learners will be very diverse from case to case, it is inevitable to measure these differences and establish their effect on the outcomes (pillar 3).

4   Model use

The model has played an important role in shaping the pilots and the pilot evaluation, and it will continue to do so. To start with, the model has helped in setting-up the pilots. For example, a list has been set up that lists the relevant pedagogical requirements for all pilots that flow from the pedagogical models of step two. One such requirement is that in lifelong competence development teacher and assessor are separate roles. As competence assessment aims at assessing learning in all learning contexts that the learner encounters, including the competence development program followed by the learner, the assessor will often not be the teacher, as there often will be no teacher. The idea is also to separate the two roles to guarantee an independent judgement. At the beginning of the pilot set-up, this feature of the pedagogical model made it clear to the pilot coordinator of the first pilot, that in their pilot, the role of teacher and assessor was not separated: teacher and assessor were the same person. Furthermore, after reflection, the pilot coordinator decided to separate both roles, to guarantee a more independent judgement.

The model helps to clarify, and therefore to handle, differences between different stages of implementation and differences between pilot sites. Imagine that a model would only consist of the envisaged infrastructure on the one hand and the learning outcomes on the other hand. Compared to Figure 1, such an evaluation model is a very impoverished model. Yet, all too often program evaluations more or less use such an impoverished

model, distinguishing only between 'treatment' and 'outcomes'. However, such an impoverished model mixes up differences between several steps of implementation, thereby increasing the error considerably. Furthermore, in a multisite situation, an elaborated model as in Figure 1 is needed to pinpoint the differences and thereby make them manageable. Simply stating that the implementation at different sites will be different, is not enough, and will make comparative analysis very hard.

Currently, the model plays an important role in clarifying the program theory. Above, we presented some of the propositions that we suppose are part of the program theory. Up till now, the program theory and its propositions have mainly been derived from the formulation of the TENCompetence objectives and solutions in the TENCompetence domain model and in the project's description of work. Currently, these propositions are being checked with the initiators of the project. One purpose of the evaluation is to validate the program theory, and therefore we must be sure that we are testing the right theory.

Another major role of the model is in focusing the evaluation. As the implementation of the elements of the model can be done in so many ways, elaboration of the model leads to a large list of opportunities for evaluation. Having this list is a first step in focusing, which will consist of selecting the most important possibilities from the list.

Finally, the model helps in looking for comparison with a 'control group' in a way that makes sense. Obviously, it doesn't make sense to compare a group of people who follow a competence development program using the TENCompetence infrastructure to a comparable group of people who do not follow such a program. Of course, the program will have an effect: it would be very strange if people worked on developing a competence for a while, and this does not have any effect (Patton, 1997). The model provides clues to useful comparisons. It makes clear that it is the intended ways in which the infrastructure is used, based upon the underlying pedagogical models of step 2, that are supposed to make a difference. One way of testing this, is to compare a group of learners who use the infrastructure as intended, and one group who use the infrastructure, in which the TENCompetence models have not been implemented. For example, one may compare learner who are enabled to choose their own learning path, versus learners who cannot do this.

5   Conclusions

In this paper, we have presented a theory-driven model for multi-site pilot evaluation. We have demonstrated features of the model and we have shown how the model is used in designing the pilot evaluation. We have shown that the features of the model, although derived from the theory of social program evaluation, can be very useful in evaluating a technical and organizational infrastructure for lifelong competence development.

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Pedagogically informed metadata content and structure for learning and teaching

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Abstract: In order to be able to search, compare, gap analyse, recommend, and visualise learning objects, learning resources, or teaching assets, the metadata structure and content must be able to support pedagogically informed reasoning, inference, and machine processing over the knowledge representations. In this paper, we present the difficulties with current metadata standards in education: Dublin Core educational version and IEEE-LOM, using examples drawn from the areas of e-learning, institutional admissions, and learners seeking courses. The paper suggests the preliminary expanded metadata components based on an e-learning system engineering model to support pedagogically informed interoperability. We illustrate some examples of the metadata relevant to competency in the nurse training domain.

Keywords: metadata, competency, pedagogy

1   Introduction

In recent years, a variety of materials, tools, and learning environments have been created and installed in schools, universities, and organisations to support learning. Mostly these have been created around e-learning content and collaborative learning activities like a virtual classroom [1]. Learning activities aim at maintaining or developing a learner's competence, and there are consequent processes of seeking and interpreting evidence to decide where the learners are in their learning, where they want to go, and how they can get there. In order to support these activities and objectives, appropriate metadata content and structure are required for storing, organizing, and sharing pedagogically-related data. A difficulty with current metadata standards for learning objects, learning resources, or teaching assets is their lack of pedagogically-relevant content and structure.

Establishing an appropriate model of metadata to support e-learning is challenging due to the wide-ranging nature of pedagogically-related data and activities, and philosophical differences of opinion amongst experts about what might be considered a relevant pedagogical approach. We deal with these difficulties by taking a general, pedagogically-neutral model of learning and teaching, and to use the model to suggest the necessary metadata content and structure.

2   Some areas of difficulty in E-learning

2.1 E-learning

E-learning remains content-focussed and assessment-oriented. For example, a PDF document is placed into a Virtual Learning Environment (VLE) and students are later required to answer some multiple-choice questions about its content. While we may say that students need to "know" or "understand" the document, exactly how should they be assessed? What is the place of the document content in the curriculum? What are the learning activities which we expect of the students as they engage in their study of the document?

In addition to modelling subject matter content and assessments, this requires modelling the link between the subject matter content and the assessment of that content. In turn, this requires modelling the intended learning outcomes to identify and integrate appropriate subject matter content within the broader teaching and learning context of unit, course, and programme. Such modelling also provides a model of learning activities.

2.2 Institutional admissions

Institutional admissions typically require structured personal profiles, where a prospective student identifies their current competencies and achievements. Matching such a profile against a course's entry expectations of pre-requisite competencies remains the time-consuming and potentially inaccurate job of an admissions tutor, made more difficult by the often incomplete and imprecise expression of such prerequisites.

A usable model of prerequisites would allow the better expression of both course requirements and students' profiles and their correspondingly better match. A usable model would also facilitate the structured accreditation of prior learning, both experiential and certificated, and the processing of structured e-portfolios which instantiate the resulting claimed learning.

2.3 Learners seeking courses

Learners seeking courses which match their interests, or engaging in professional development planning, often have difficulty discovering appropriate and relevant courses because of the exceptional variability in course description, and the inadequacy of their ability to express their interests or required development in any corresponding way.

A usable model for structuring course purpose and intent would adequately characterise a course by its prerequisites, intended learning outcomes, the competencies it expects to develop in its students, and the anticipated achievements of its successful students at each of a range of levels.

3   Metadata standards for education

Generally, "metadata is information about a resource, either physical or digital" [2]. In the case of educational resources, metadata refers to information about resources used in the context of learning, education, and training [3]. Metadata helps people organize, find,

and use resources effectively. For example, metadata helps users of an educational digital library find resources in a particular subject area at a particular grade level that can be used on a particular computer. Metadata can be used to identify multi-lingual resources or to inform a user about where and how to purchase a resource. A software application might use metadata to identify which resources are identified with a particular unit of study. Without metadata, managing these tasks would be difficult or impossible.

There are two important accredited metadata standards in the domain of education and training [4], namely Dublin Core (DC) educational version, and Institute of Electrical and Electronic Engineers Learning Object Metadata (IEEE-LOM).

In order to promote reuse of learning content, automated processes for metadata creation and search are required so that these burdens can be alleviated by machines [5]. However, it is not possible within the existing standards to represent sufficiently fine grained semantic information about learning resources in order to allow the selection of appropriate learning materials from a number of resources within some domain [6].

4   Metadata content and structure

We identify the difficulties illustrated earlier in e-learning and with current standards as a lack of pedagogically-relevant metadata content and structure. An approach to dealing with this difficulty is to take a general, pedagogically-neutral model of learning and teaching and to use the model to suggest relevant metadata content and structure. Figure 10 illustrates the E-Learning SYstems Engineering (ELSYE) model of the "learning transaction" [7], based upon the "conversational" theory of Laurillard [8].

The key contributions of this model of the learning transaction are that it identifies "purpose" as an essential component of a learning and teaching situation, and it identifies the five essential components of the interaction between the teacher and learner roles as "tell", "show", "ask", "response", and "feedback" [9]. It is suggested that information about these components, and about the transaction as a whole, should form the basis of the pedagogically-informed metadata which would be relevant to any description of content or process in a learning and teaching situation.
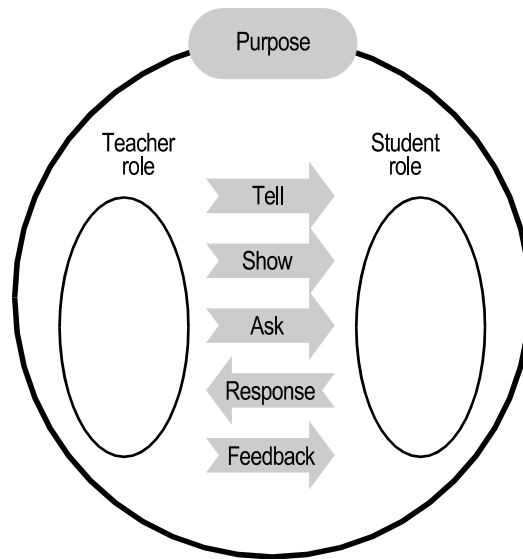
Figure 10 ELSYE model of the learning transaction

The content and design of a learning transaction, of the "tell", "show", "ask", and "feedback", depend upon four considerations:

- characteristics of the learner
- characteristics of the media and methods being used in the learning and teaching situation
- characteristics of the subject matter content
- the intended learning outcomes.
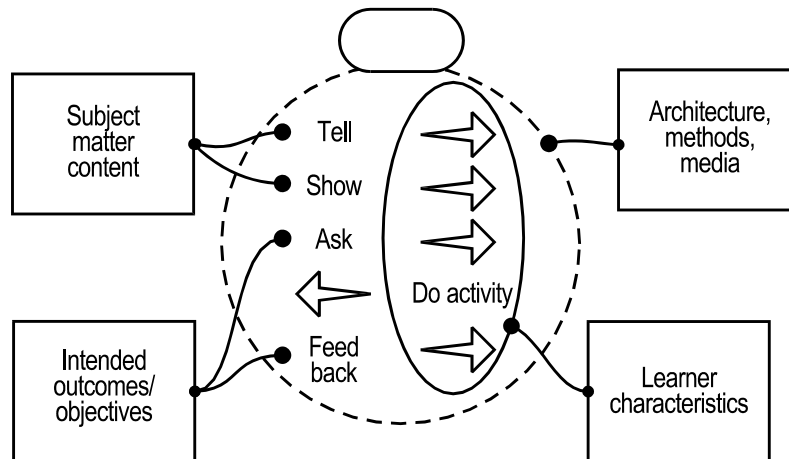
Figure 11 Determiners of the design and content of a learning transaction

Figure 11 illustrates the connection between the components of the learning transaction model and the considerations for the design and production of learning and teaching materials.

In preliminary stage, the purpose, content, and design of a learning transaction may be described by the elements illustrated in Figure 12. These elements may be taken as the basis for the metadata which would be relevant to any learning object, learning resource, or teaching asset.

In practice, metadata tagging typically needs to be undertaken from a controlled, possible extensible, vocabulary, so underpinning the metadata elements are ontologies for each category, as illustrated in Figure 13.
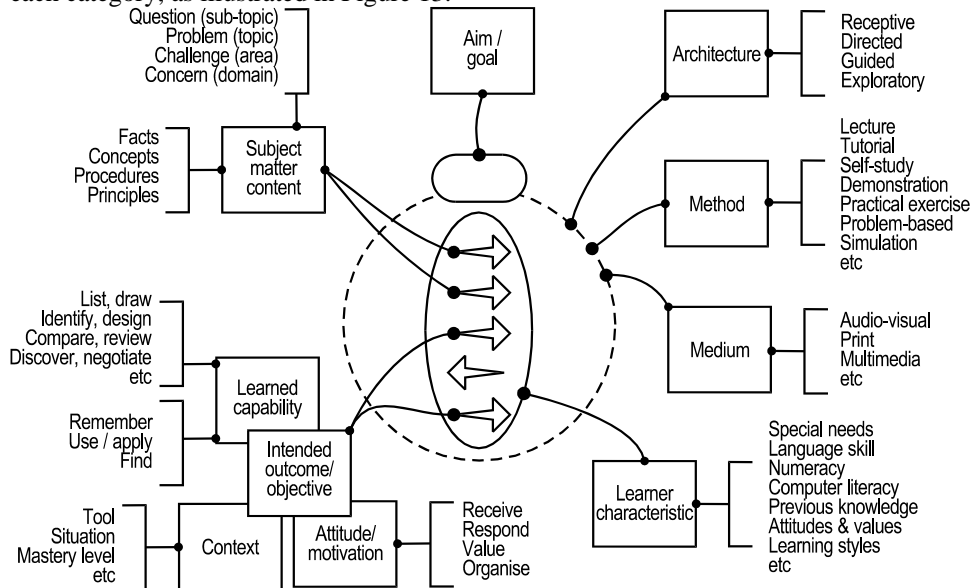
Figure 12 Metadata derived from the ELSYE model
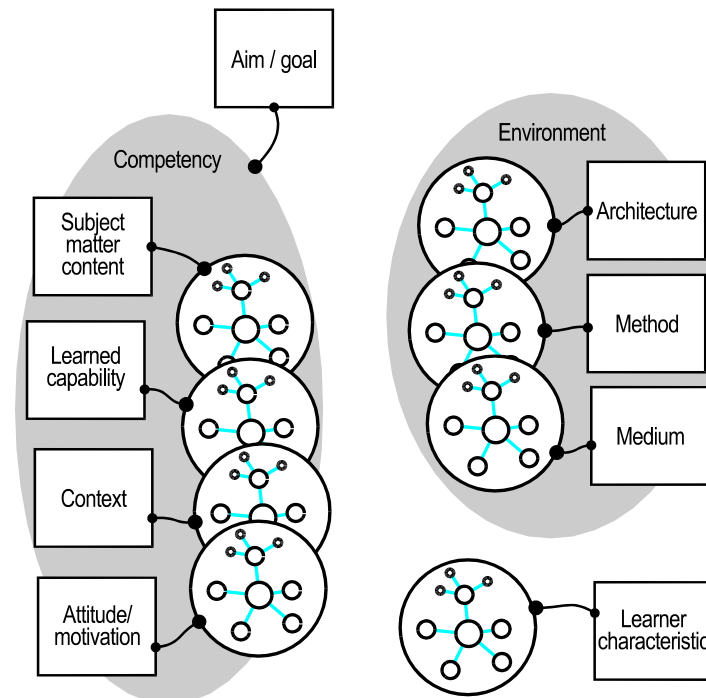
Figure 13 Ontology underpinning for metadata

These ontologies provide at the least the controlled vocabularies for expressing the metadata elements (possibly drawing upon the JISC Pedagogical Vocabularies Project [10]). Interestingly, the ELSYE learning transaction model suggests that the purpose of a learning object, learning resource, or teaching asset may be expressed as a high-level statement of the competencies which it intends to support. In turn, a competency is a compound statement incorporating the components of subject matter content, learned capability, and attitude or motivational state, to give expression to the common statement that a learner's "true" understanding of a domain consists of their knowledge, skills, and attitude [11]. The fourth component of a competency, "context", acknowledges that "understanding" is always contextual and depends upon a variety of factors which may require explicit expression if the use of a learning object, learning resource, or teaching asset in any learning and teaching situation is to be adequately characterised.

To illustrate the general mechanism, we choose competencies from health care because they are amongst the most sophisticated and challenging to implement [12]. Student practitioners typically undertake a number of clinical placements during their training, and their competencies are typically assessed by geographically dispersed and time-constrained mentors and supervisors. In this scenario, the adoption of electronic competency records and their interoperability will be enhanced via adherence to emerging standards for competency definition.

We used the Royal College of Nursing (RCN) competency for developing paediatric epilepsy nurse specialist service as an example, and implemented it using XML format and the ELSYE model. XML was chosen to provide interoperability and exchange. The example implemented is shown in Figure 14.

5 Benefits and impacts

The benefits of pedagogically-informed metadata are expected to include better matches between knowledge required and knowledge supplied, between knowledge required and knowledge taught, and between personal knowledge gaps and corresponding mass-individualised educational and training provision.

Benefits and enhancements are also expected in life-long learning and personal and professional development, since the proposed metadata structure is readily extensible to include learning and development from informal learning in hobbies, sports, and social activities.

To take an example from a European Union perspective, workforce mobility and the transfer and development of skills across member states and across organisational sectors would be facilitated, along with personal and professional development and job progression within employers and organisations. Employers' requirements may be better matched with workers' true abilities.

```xml
<?xml version="1.0" ?>
- <Competence>
  - <definition>
    + <ID>
    - <name>
      + <statementtext>
      </name>
    - <description>
      - <statementtext>
        <langstring xml:lang="en">Demonstrate basic understanding of epilepsy syndromes in General clinical management</langstring>
        </statementtext>
      </description>
    </definition>
  - <source>
    + <ID>
    + <name>
    - <reference>
      - <statementtext>
        <langstring xml:lang="en">PENS competency framework</langstring>
        </statementtext>
      </reference>
    </source>
  - <capability>
    + <ID>
    - <name>
      - <statementtext>
        <langstring xml:lang="en">Demonstrate basic understanding of epilepsy syndromes</langstring>
        </statementtext>
      </name>
    </capability>
  - <subjectMatterContent>
    + <ID>
    - <name>
      - <statementtext>
        <langstring xml:lang="en">epilepsy syndromes</langstring>
        </statementtext>
      </name>
    </subjectMatterContent>
  + <evidence>
  - <tool>
    - <ID>
      + <statementtext>
      </ID>
    - <name>
      - <statementtext>
        <langstring xml:lang="en">discussion with mentor and patient</langstring>
        </statementtext>
      </name>
    </tool>
```

Figure 14 RCN competency

6   Applications

Pedagogically-informed metadata would revolutionise the support for technology-enhanced learning and teaching. We can imagine the combination of well-described content with tools and services to yield configurations of useful and effective learning and teaching materials and environments involving machine processing and machine reasoning over semantically rich knowledge representations of pedagogic content.

7   Conclusion

Awareness in the sector of education and training on the issue of learning technology standardization is growing fast particularly in the use of metadata. However, with awareness of the importance of these issues also seems to grow some confusion and misunderstanding.

We have looked at the current areas of the difficulties associated with metadata. The lack of pedagogically-relevant content and structure with current metadata standards in education effectively retards the development of technology-enhanced learning. We propose metadata based on a simple but pedagogically sound model of the learning transaction, and find rich suggestions. Such metadata can then support machine processing, flexibility and extensibility, reasoning and interoperability. The paper also gave some examples of competency-related metadata. We have described some related topics involving benefits, impacts and applications of the proposed metadata.

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ASSESSMENT AND MONITORING

Enhancing IMS QTI Assessment with Web Maps

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Abstract: Despite the importance of maps in Geography education, current eLearning systems do not take benefit from the possibilities that web maps offer. In this paper we describe an IMS QTI assessment engine enhanced with web maps from Google Maps. The system enables the user to interact with the map to answer questions, providing a more natural interface for geographic information. The concept of map interaction has been introduced to represent the different ways of processing the student actions on the map. Depending on the selected map interaction, different spatial operations are applied to validate the correctness of responses.

1   Introduction

Humans have used maps to represent parts of the Earth since the Stone Age. During these millennia, the science of Cartography has evolved from portraying simple representations on walls to the extremely precise real-time-populated interactive web maps we can find today. Maps are the most widely used tool in Geography to represent those features and phenomena that have a spatial component. Maps are also used in other disciplines where space may be an influential factor such as History, Economics and Business, Sociology, Politics, Biology or Environmental Science, among others.

From a pedagogical perspective, maps also play a key role in Geography education. In fact, understanding maps is a key competence that children have to acquire. Maps are widely used in Geography learning activities and content. Maps are needed by K-12 education students to understand their local and global environment, and how human activities take place in these environments. Higher education and life-long learning also make frequent use of maps.

However, the use of maps in eLearning has been very limited, mainly constrained to non-interactive still images. Web map servers offer the possibility of incorporating more elaborate maps in the learning process, with more interactivity and learning possibilities.

The importance of maps in Geography education can be extended to assessment activities, since maps are usually needed to evaluate the acquisition of competences in

Geography and related fields. In this work we focus on how maps can be used in the process of assessment in an eLearning platform. We are interested in an assessment system supporting the visualization of web maps and providing the typical interaction tools such as zoom in or zoom out. Furthermore, the system has to enable students to answer questions by interacting with the map in different ways:

- clicking on key elements on the map
- sketching points, lines or polygons on the map to represent geographic elements, such as cities, rivers or countries respectively.

Section 2 describes the main specification for interoperable assessment, IMS QTI. It also describes APIS, the engine that we have upgraded and used in our experiments with mapping services for assessment. Section 3 focuses on the main approaches for serving maps on the web: the OGC Web Map Service specification and Google Maps. Section 4 presents our approach of combining the APIS engine and Google Maps through a middleware that we have developed. Finally, Section 5 summarizes the main conclusions and states some lines for future work.

2   IMS QTI and the APIS engine

Question and Test Interoperability (QTI) [1] is the IMS specification for assessment. It provides a data model for the representation of questions (items) and tests and their corresponding outcomes. It enables the exchange of questions and tests between authoring tools, item banks, test composition tools, learning systems or assessment delivery systems, to name a few. Although the model is defined in abstract terms, an XML implementation is also provided in the specification.

The main elements of the QTI data model are:

- Item: it is the smallest interchangeable QTI element that stores the question presented to the user along with the associated metadata such as the reproduction instructions, user answers processing mode, hints, and feedback.
- Section: it represents a composite part of the assessment test or exam.
- Test: it is an entire QTI instance that embodies a single assessment test. Its structure is divided into sections and subsections and contains sequential information along with the method(s) to use for combining individual questions scores/marks to form the overall test grade.

The last two versions of the specification are 2.0 and 2.1. QTI 2.0 focuses on the representation of individual questions, introducing a long list of interactions. An interaction describes how the user "interacts" with an individual question, and can be seen as a type of question. An example of interaction, probably the most usual, is the simple choice question, where the user can select just one from several possible responses to the question, and where just one of them is correct. On the other hand, QTI 2.1 (still in public draft phase) deals with tests and their internal organization in sections. QTI 2.1 also defines complex ways of producing results reports for a whole test.

An engine is necessary to run QTI tests. A QTI engine is the software component responsible to manage the QTI data model, processing the XML file and generating the outcomes according to the user actions. There are two main open source implementations of QTI engines that we describe now.

The APIS (Assessment Provision through Interoperable Segments) QTI 2.0 engine [2] was originally created by Strathclyde University. A modular item-rendering engine was defined, although only some of the most widely used interactions were implemented. This engine addresses the operations required by potential tools defined in the Open Knowledge Initiative (OKI) [3] and IMS Web Services [4].

The R2Q2 (Rendering and Response processing services for QTIv2 questions) project [5,6] has been developed more recently by the University of Southampton. It is a new implementation built from scratch, aiming at providing a complete renderer and response processing engine, properly structured. Due to its function-modular design (Renderer, Processor,...) and use of internal Web Services, the system facilitates future enhancement and can be changed to suit any application.

However, both implementations are limited to the QTI 2.0 specification, and consequently can only process individual questions. We have largely upgraded the APIS engine to making it compliant with QTI 2.1, introducing new functionalities mainly referring to: test context instead of just questions, a wide range of new elements related to the test level, new and more complex response processing and new types of interactions. This new version of APIS is available at Source Forge at http://sourceforge.net/projects/newapis. A more detailed description of the structure of the new APIS engine can be found in [7].

This upgraded APIS engine will be the base for processing those questions needing mapping services, as described in Section 4.

3 Google Maps and other mapping services

Serving maps on the Internet has become very popular in the last few years. A multitude of implementations of mapping servers exists, both commercial and open source, using different programming languages. In this context of heterogeneous tools, the Open Geospatial Consortium (OGC) is the international consortium of companies, governmental agencies and universities that is leading the definition of consensus standards in the field of geospatial services. Several OGC specifications have become ISO standards. In the domain of map servers, OGC has developed the Web Map Service specification (WMS) [8], which defines a service-based interface for a standard map server consisting of the following three main services:

- *GetCapabilities*, which returns metadata related to the server
- *GetMap*, which returns a map (an image) given some parameters as the coordinates of the centre of the map, zoom level, …
- *GetFeatureInfo*, which returns the information of a given feature(s) appearing on the map, given a pair of pixel coordinates

Any WMS-compliant server may define other services, but have to implement these three basic ones, that in fact are sufficient to develop an interactive on-line map. There are several commercial and open source implementations of WMS. MapServer [9], developed by the University of Minnesota, is the most widely used open source implementation of WMS. WMS has been adopted by ISO as the ISO 19128 Geographic information - Web Map server interface [10], becoming a normative international standard.

However, the appearance of Google Earth and Google Maps has changed the world of map servers. Google Maps is a simple web-based map viewer, while Google Earth is a richer desktop application that provides attractive 3D visualization, as well as other extra features. Both tools offer free world-wide cartography including street-level information for most Western countries, as well as satellite images at different resolutions. Google has also defined KML, a simple XML-based file format for storing vector-based (points, lines and polygons) geographic information. Users around the world have produced KML files to show their favourite spots, routes, etc, that can be seen on the free cartography that Google offers.
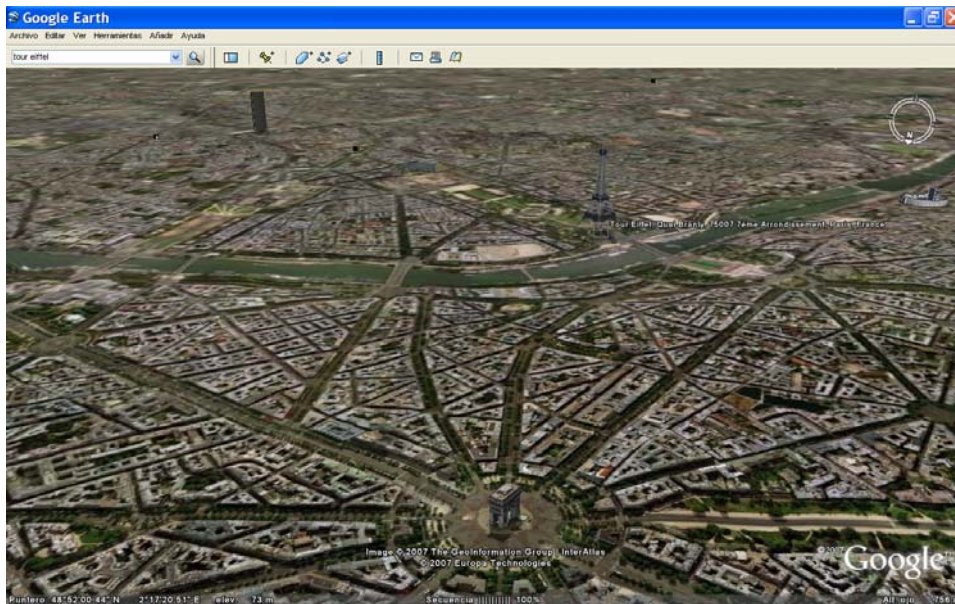
Figure 1. 3D view of Paris in Google Earth, including several 3D models of famous buildings

Although Google Earth and Google Maps are not compliant to OGC standards, their free cartography, simple but rich interface and the possibility for users to add their own geographic data, have massively popularized these tools.

Furthermore, Google Maps provides a simple JavaScript API that enables third parties to publish the location of spots on the map, and to connect to other web services through AJAX calls. An example can be seen in the Figure 2, where Google Maps is used to show the position of San Francisco buses in real time.
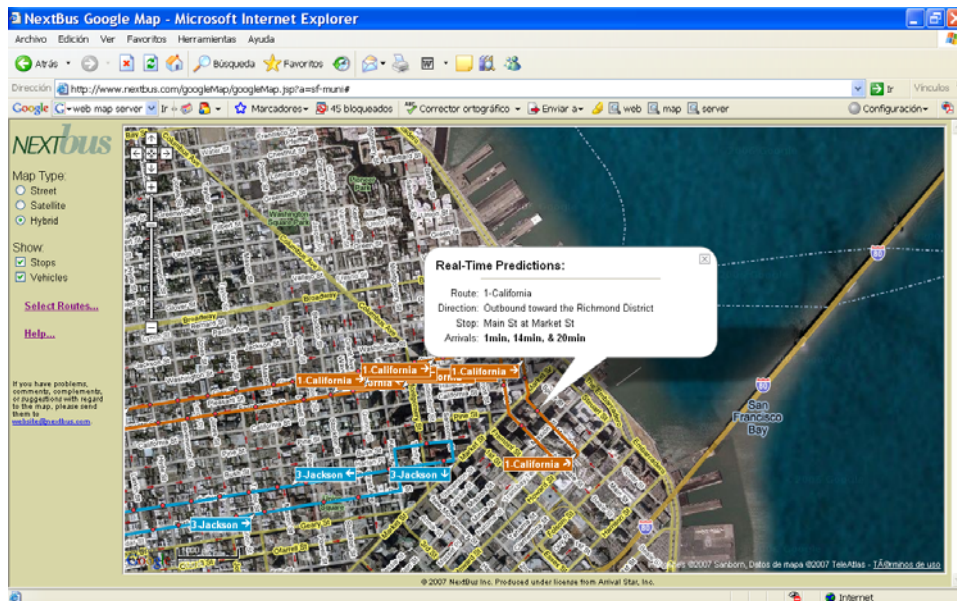
Figure 2. San Francisco buses in real time, at http://www.nextbus.com/

Due to its popularity and easy API, we have decided to build the first prototype of our map-enabled QTI service on Google Maps. Nevertheless, as it will be discussed later, our plans include extending the middleware to support OGC-compliant map servers too.

4   Connecting APIS and Google Maps

The connection between APIS and Google Maps is carried out through a middleware that we have developed. This middleware is responsible for generating the Google Maps JavaScript functions to show the map. It also processes the actions of the user on the map and converts them into QTI responses that can be processed by APIS. The middleware encapsulates all the Google Maps code, and consequently the APIS engine does not need changes. Providing support for WMS would require modifications in the middleware, but not in APIS.

A map can be inserted into a question through the tag *map* in the *itemBody*, in the same way as an image is inserted. The *map* element has an attribute *src* that contains the URL of a file describing the map. This file contains the coordinates of the centre of the map (according to the WGS84 reference system) and the zoom level (1 is world-wide level and 18 is street-level). Other parameters can also be set concerning visualization aspects.

```
<Centre>
    <Latitude>40.346544</Latitude>
    <Length>-3.757324</Length>
    <Zoom>5</Zoom>
</Centre>
```

Once APIS detects a *map* tag, it calls the middleware that parses the XML file and generates the JavaScript code necessary to set the right map. This JavaScript code is inserted into the web page that presents the question. For some questions this is the whole process since only showing the map is required, with no interaction, exactly like an image. Figure 3 shows an example. Note that, unlike a still image, an interactive map enables the user to freely put the displayed area in context by using zoom controls or by moving the map to explore neighbouring areas. Nevertheless, the teacher can lock these possibilities when necessary, through some parameters in the XML file.

Figure 3. Example of a simple choice question showing a map from Google Maps

However, we are mainly interested on more complex questions that have to be answered by the user by interacting with the map. As an example, we can see the question in Figure 4, where the user is required to click on the largest Catalan city.

Figure 4. Example of a simple choice question requiring the user to interact with the map

We can observe that, as in the example of the Iberian Peninsula above, this is a simple choice question, with four choices and just one valid one. However, the four options are not explicitly included in the text below the map, but are provided as markers on the map. The user is required to click on the markers to answer the question, providing a more natural interaction.

The QTI file contains the information indicating that the right answer is Barcelona, in the *responseDeclaration* element. However, the four choices are not explicitly declared in the *choiceInteraction* element, since they should not appear in the text below the map. Instead, choices are declared as *GMapInteraction*, which indicates to APIS that the interaction for this question is defined in the map description file and consequently, passing the responsibility to the middleware. The middleware generates the JavaScript functions that handle users clicks, and converts these clicks to a string with the selected choice (Barcelona, Girona, Tarragona or Lleida) that will be sent back to APIS. APIS then checks whether the selected choice is the right answer (Barcelona) or not, in the normal way. Note that the only change introduced to APIS is the detection of the *GMapInteraction* type of choice, while all the geographic logic is managed by the middleware through JavaScript functions.

This method enables the use of maps in other types of QTI interactions. For instance, the following image shows an *orderInteraction*, where the user is prompted to order the four Catalan capitals according to their population.

Figure 5. Example of an order interaction requiring the user to interact with the map

Furthermore, we can define more complex ways of interacting with the map. In the following example, the user is prompted to click on Italy, and there is an invisible polygon defining the area that is considered as the right answer.

Figure 6. Example of a new type of question: *PointIntoPoligon* map interaction

Note that although this can be modelled as a simple choice question with two possibilities: *Italy* (right choice) or *outside Italy* (wrong choice), we have to define how this has to be handled in Google Maps. This is an example of what we have called *map interactions*, which are different from question interactions. A map interaction defines how a given answer and the solution are processed (through spatial operations) to validate the correctness of the answer, and it is defined in the XML file describing the map. In this case, the map interaction is a *PointIntoPolygon*, and has two parameters: the polygon defining Italy, and a Boolean value indicating that the polygon is kept hidden. Note that the middleware, and not APIS, is responsible for evaluating the map interaction, i.e. checking whether the user has clicked inside the polygon that defines Italy or not.

We have defined a list of other types of map interactions, that basically correspond to the different topological relations. In the following example, where the user is prompted to draw the border line between Spain and Portugal, the map interaction is a *LineIntoBufferedLine*. In this case, the solution is a line that is widened (through a buffer spatial operator) to a certain distance, for instance 50 km. This distance is set in the XML file. The middleware has to check whether the line that the user has drawn is inside the buffered line or not.
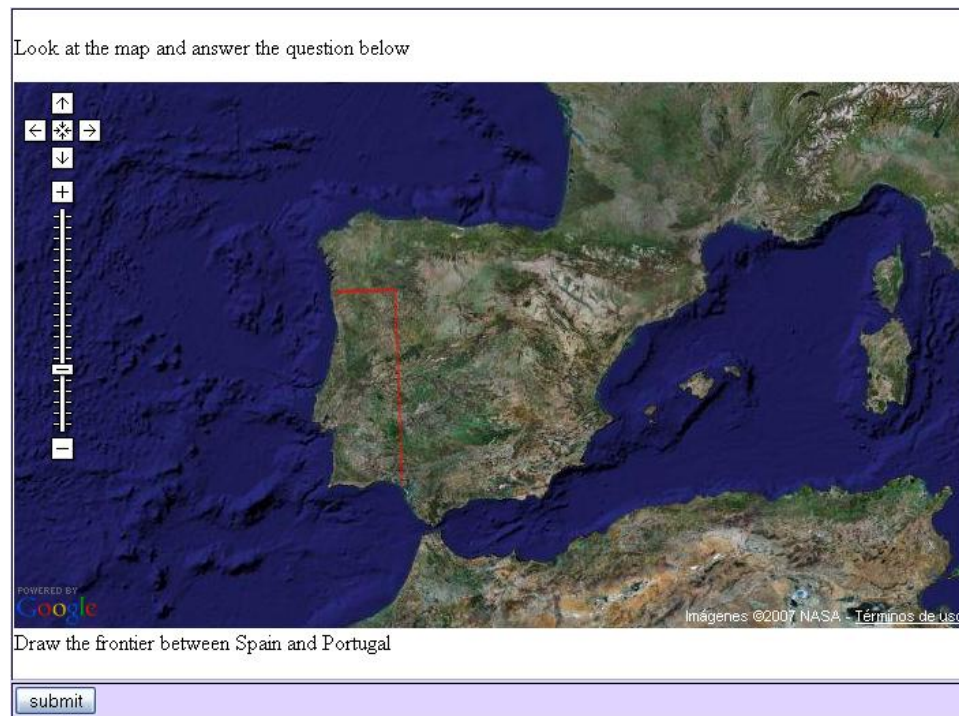
Figure 6. Example of *LineIntoBufferedLine* map interaction

5   Conclusions and future work

Maps are an important element in Geography education. An eLearning approach should not skip both the necessity and the potential of the use of maps in Geography learning. In particular, assessment can be improved if interactions with maps are supported, enabling users to click or sketch on maps.

We have presented a middleware-based approach to connect the APIS QTI engine and Google Maps. This approach enables the definition of mapping services for assessment that involve just some minor changes to the APIS QTI engine.

The use of interactive maps introduces the possibility of new ways of interaction with questions. The user can be prompted to click on markers instead of selecting text options, providing a more natural way of interacting with geographic information. Furthermore, the user can also be asked to draw sketches (points, lines or polygons) as his/her response to a question, introducing the concept of map interactions that define how the correctness of the answer is processed. This way, new types of queries not covered by QTI can be defined.

Our plans for future work related to this paper include three main lines. The first involves the development of a new middleware to support the connection to WMS servers, such as MapServer. The second line is related to a new editor for QTI 2.1 that we are currently developing. We plan to include a module enabling authors to graphically create map-enabled questions and map interactions. Finally, as a third line, we would like

to explore the definition of new types of questions, with other map interactions including support for more geometries and spatial operations.

In addition, from our point of view, an eLearning environment should support the combination of different standards and specifications to provide richer content and interactivity. We think that our work on enhancing assessment tests with maps has a more general aim, presenting an approach for integrating different specifications in an eLearning (assessment in this case) environment. In this line, we plan to integrate other services in our IMS QTI engine, following the middleware-based approach we have used here, to enable a collaborative and multimedia assessment. On the other hand, we also plan to extend our current middleware to be integrated into an IMS Learning Design (LD) [11] engine, again as a first exploratory example of combining different specifications with LD.

Acknowledgment

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A support model for question-answering

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Abstract. Tutors have only limited time to support the learning process. In this paper, we introduce a model that helps answering the questions of students. The model invokes the knowledge and skills of fellow students by bringing them together based on the combination of questions posed and their study progress; it supports the process with text fragments selected from the material studied. We will explain the model and the use of Latent Semantic Analysis (LSA) to select and support the peers. Finally, we will discuss the results of a calibration and simulation of the model and present the first results of an experiment.

1   Introduction

In modern learning settings, students typically spend a significant amount of time learning online. The advent of the knowledge economy and the individualisation of our society are two leading factors that underpin the increasing demand for flexibility: students want to be able to study at the place, time and pace of their own choosing (logistic flexibility); also, students are unwilling to submit themselves to pre-planned, rigid programmes, but want their prior competences honoured and their specific study plans catered for (subject matter flexibility). However, as in regular settings, students will have questions on where to start, how to proceed, how to understand and apply the available study material or will want to have their contributions assessed. In this paper, we will concentrate on one element of this challenge, to wit, answering questions related to the content studied. For a tutor, this is considered a time-consuming and disruptive task (De Vries *et al*, 2005). Yet, learning may improve if learners can ask questions and receive timely and relevant feedback (Howell, 2003).

In our model (Van Rosmalen *et al*, 2006; Kester *et al*, 2007) we seek to solve content-related questions by involving peers in answering them (peer tutoring). To that end, we identify appropriate and available students as well as documents, and bring these together in a so-called *ad hoc, transient* community. Such a community is *ad hoc* in that its only purpose is to solve a particular question; it is transient in that it vanishes the moment the question has been solved. The model distinguishes (Table 1) six main steps of which step 2 depends on LSA. In the following section we will introduce the current implementation, next we will discuss the results of a calibration and simulation of the

model and finally we will conclude with the first results of a still ongoing experiment with approximately 100 students in a Learning Network on 'Internet Basics'.

Table 1: The main steps of the model.

Pre-condition	A Learning Network (LN) with a set of Activity Nodes (ANs) and a set of users with their profiles indicating their progress with regard to the topics
Main steps	1. *Anne* poses a question.
	2. The *system* determines:
	- the most relevant text fragments;
	- the appropriate ANs;
	- the most suitable users.
	3. The *system* sets up a wiki with the question, the text fragments and guidelines.
	4. The selected *users* receive an invitation to assist.
	5. *Anne and the users* discuss and phrase an answer in the wiki.
	6. If answered (or after a given period of time) *Anne* closes the discussion and rates the answer.
Post-condition	The answer is stored.

2   Model implementation

The prototype of the model (Figure 1) consists of five modules. For the students we have a course (LN), its topics (ANs) and a question interface (AskCQ) in Moodle (http://www.moodle.org). Additionally, each time a question is posed, a wiki is made available that includes the question and three documents selected from the course material. The wiki is populated with a selection of users who are invited to help. In addition, in the background, we have three modules: a general text parser (GTP; Giles *et al*, 2001), a GTP calibrator (GTP Usability Prototype –GUP-; De Jong *et al*, 2006) and a tutor locator (ATL; De Jong *et al*, 2007). We use GTP, an LSA implementation, to map the questions on the documents in the course. The GTP module returns correlations between the question and documents. The GUP module has been built to ease the calibration. Finally, the ATL module takes care of the selection of the peer users who will assist. The selection is based on a weighted sum of four criteria that are derived from the users' background and performance. The designer can adjust the weights.
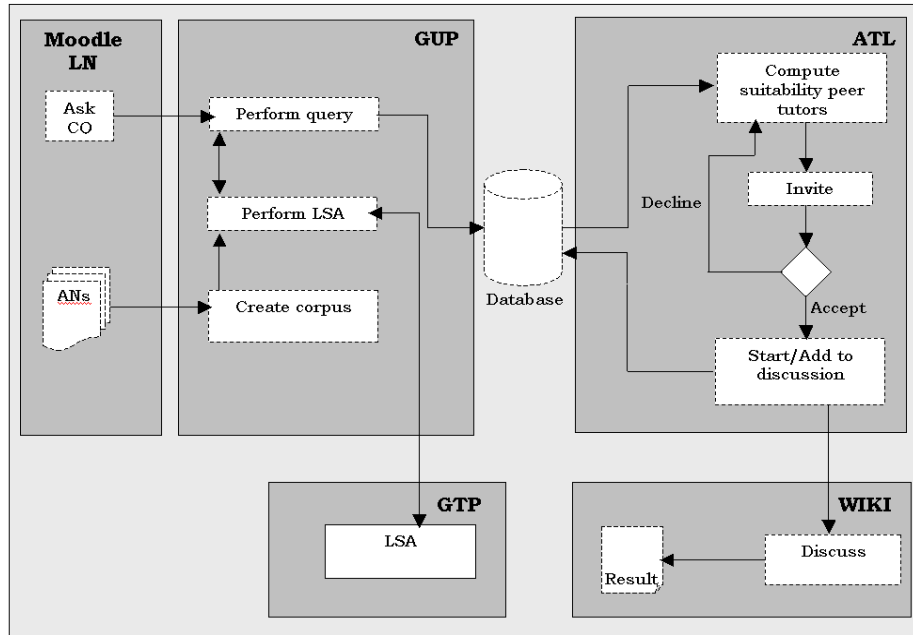
Figure 1. The main modules of the model.

The model covers three phases. In the design-phase, the working context is defined. All text of the LN is captured and put into a corpus for further analysis and all parameters, the LSA and the peer selection parameters, are set. Ideally, the contents of the LN can be captured automatically if the ANs are specified according to a standard such as IMS Learning Design. The question-phase starts when a user poses a question (e.g. "when I register for a particular chat room, does my registration allow me to use several pseudonyms?"). First, the ANs are identified to which the question fits best. This is done by mapping the question with LSA on the documents of the corpus and to look for the three documents with the highest correlations. Later, the same three documents are given to the ad hoc community to help the users get a quick overview of relevant documents in relation to the question. We chose three documents because three should suffice to be of assistence and should not hinder being all read by the supporting peers. Next, knowing to which topic the question fits best, the ATL module can identify peers who are competent in the pertinent AN(s). ATL selects 2 users who, according to a weighted sum of four criteria, i.e. *tutor competency*, *content competency*, *availability* and *eligibility* (Van Rosmalen *et al*, in press) are best equipped to answer the question. Finally, in the answer-phase the peers invited, discuss and formulate an answer.

3   Calibration and a first simulation

To assure that our prototype is viable we calibrated the LSA-parameters, and simulated and tested two key aspects of the model. First, we checked how well we can use LSA to identify the topic of a question (i.e. to which ANs a question belongs) and to select text

fragments useful for answering the question. Second, we checked if the peer selection criteria met our expectations. The domain of the LN we used is 'Internet Basics', a collection of texts, links and tasks that aim to instigate a basic understanding of the Internet (Janssen *et al*, 2007). It contains 11 topics, each of which introduces a different aspect of the Internet. The topics consist of an introduction, exercises, references to external web pages for further study and an assessment.

For the simulation, we formulated a set of 16 test questions, each related to exactly one AN. The prototype identified the correct AN for 12 out of the 16 questions (75%). Moreover, two developers of the Learning Network in question, evaluated the suitability of the text fragments, three for each question, that the prototype suggested. For 7 of the questions, one or more text fragments were identified that in their opinion were useful for answering those questions. The experts also indicated that 5 of the 16 questions posed were beyond the scope of the contents of the AN studied (please note questions being on topic but out of scope for a course will also happen in real practice). Taking this into account, the score is 7 questions with useful text fragments out of a total of 11 (about 60%, for details, see Van Rosmalen, 2006).

To test the peer selection criteria we created five learners (Table 2) and we assigned a set of test values to the parameters of the peer selection formula (for details see Van Rosmalen *et al*, in press). Next, we had learner 1 (L_1) twice 'ask' one of the 16 question mentioned above. The question was related to AN2. For the first question the learner with the highest rank was selected. The results of the test showed, however, that we can balance the selection of peers with the help of workload and eligibility. In selection 1 the value of eligibility favoured Learner 2 (L_2) over Learner 3 (L_3), i.e., it prioritised the selection of a student in the same study-phase. However, if we pose the question again the balance was shifted due to the workload of Learner 2.

Table 2. Position of learner L_1 - L_5 for AN1 and AN2.

	L_1	L_2	L_3	L_4	L_5
Score AN1	1	1	0.3	0	0
Score AN2	0.3	1	1	0	0
Availability (at the start)	05	05	0.5	0.5	0.5

4   Experiment

The results discussed in the section above suggested that the model delivers as expected. Therefore, as the next step we set-up an experiment first to verify the hypothesis that the task of staff in answering questions can be facilitated and significantly alleviated by following the peer-user model proposed. The assumption is that it should be possible to solve at least 50% of students' questions without staff support. For the experiment, we organised a course over 8 weeks in the LN on Internet Basics; 109 students volunteered. The students were divided at random over two groups. This, also to study the effect of different parameter settings of the student selection criteria. In group 1, we used a weighted selection of all criteria. In group 2, we only made use of the availability criteria to select peer-tutors. Students received general instructions connected to the LN and a

specific instruction on how to use the AskCQ-module for all their content-related questions. To avoid any unclear dependencies, it was decided that for the first experiment the students would not receive any incentives to use the AskCQ-module and also that we would only interfere afterwards with staff-tutors. It means that the staff-tutors would not assist during the course with answering content-related questions but that they would only rate the result of each question-answer pair.

At the moment we are halfway through the experiment. The first results are promising. In total over the two groups:

- 39 questions have been posed;
- Of which 30 questions have been resolved; 6 are being discussed and 3 questions failed because the invited peer-tutors did not react or refused the invitation to contribute;
- 25 students posed one or more questions;
- 30 students assisted in answering one or more questions;
- In total 40 students have been actively involved either posing or answering questions;
- Finally, 19 students did not show any activity, i.e. they never logged in or only looked at the general instructions.

The overall activity level with regard to AskCQ module is fair, disregarding the inactive students, the participation is close to 50%. Moreover, at least from the question poser perspective, the majority of the questions have been resolved.

5   Conclusion

In this paper, we described a model that intends to help the learner with questions that arise while studying. We described how we tested the model on two of its key aspects and the first results of an experiment with students. The test results indicate that we were able to identify the relevant ANs for a question, to select text fragments useful for answering the question, and to apply our peer selection formula to the extent that it warrants carrying out an empirical study with 'real' students. The first results of the experiment suggest that the task of staff in answering questions can be facilitated. Obviously, without a full set of data and a detailed analysis of them it is too early to draw any final conclusions.

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A Domain-specific Modeling Approach to the Development of Online Peer Assessment

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Abstract: Modelling a peer assessment using IMS LD and IMS QTI is difficult for average practitioners. In this paper, we apply domain-specific modelling technologies to develop a peer assessment modelling language, in which notations are directly chosen from the concepts and rules used to describe peer assessment. Thus, practitioners can easily understand such a high-level language and use it to specify online peer assessment. The paper also discuss some related issues to develop an authoring tool for modelling with the peer assessment modelling language and to map a peer assessment model represented in the peer assessment modelling language to a corresponding executable model represented in IMS LD and IMS QTI.

Keywords: Domain-specific modeling, peer assessment; IMS LD; IMS QTI.

1   Introduction

Peer assessment is an arrangement for peers to consider the level, value, worth, quality or successfulness of the products or outcomes of learning of others of similar status (Topping, et al. 2000). Researchers have generally agreed that peer assessment stimulates student motivation and encourages deeper learning and understanding (Topping, 1998, Gipps, 1999; Boud, Cohen, & Sampson, 2001). As e-learning is more and more popular, a number of software tools supporting online peer assessment have been developed such as Peers (Ngu, et al. 1995), Peer Grader (Gehringer, 2001), NetPeas (Liu, et al. 2001), SPARK (Freeman & McKenzie 2002), Espace (Volder, et al. 2007), Turnitin Peer Review (Turnitin), and so on.

Contrast to traditional software development approaches to peer assessment tools listed above, we adopted a process modelling approach to support online peer assessment (Miao & Koper, 2007). Concretely speaking, we use IMS Learning Design (LD, 2003), IMS Question and Test Interoperability (QTI, 2006), and assessment-specific services to model peer assessment processes. The resulting peer assessment process models with necessary resources can be played in any standard-compatible run-time environment. In comparison with typical software development approaches, our technical approach is more efficient and flexible (Miao & Koper 2007). In particular, our approach can support seamless integration of peer assessment with learning activities.

However, this technical approach has limitations. The required level of knowledge of LD and QTI and technical knowledge of process modelling for those authoring assessments is significant. To acquiring such technical knowledge is very difficult for average practitioners. In addition, if a peer assessment process is extremely complex, the modelling work will be very difficult even for technical experts (Miao & Koper 2007).

In this paper, we address the limitations of the standard-based approach by applying domain-specific modelling (DSM) technologies. As the first attempt in this direction, we develop a peer assessment modelling language for practitioners to model peer assessment processes. The remaining part of the paper is structured as follows: domain-specific modelling and peer assessment are briefly introduced in Section 2 and Section 3, respectively. Section 4 presents a peer assessment modelling language. Some issues are discussed in section 5. Finally, we present conclusions and point out the future work.

2   Domain-specific Modelling

Domain-Specific Modeling (DSM) or Domain-specific language (DSL) are more expressive and therefore tackle complexity better, making modeling easier and more convenient. More importantly, they allow automatic, full code generation, similar to the way today's compilers generate Assembler from a programming language like JAVA.
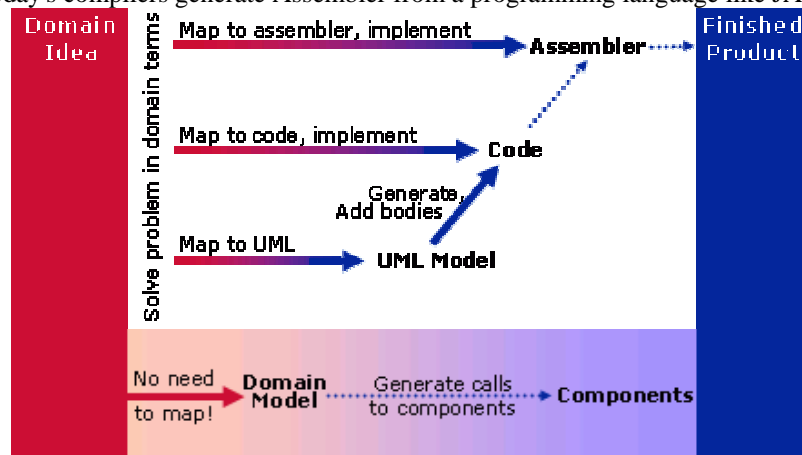
Figure 1: DSM and traditional software development approaches (from DSM forum)

DSM raises the level of abstraction beyond programming by specifying the solution in terms of concepts and associated rules culled from the very domain of the problem being solved. The final software products are generated from these high-level specifications (DSM forum). Notations in a domain-specific model are a whole level of abstraction higher than those in Unified Modelling Language (UML). As shown in figure 1, normally software developers will implement the final product by mapping the domain concepts to assembler, code, or UML model. By adopting DSM, a meta-model of the problem domain will be constructed as a modeling language by domain experts. Domain-specific code generators and executable components will be developed by experienced technical experts. Then, less experienced developers can use the meta-model to build actual solutions, which will be automatically transformed into existing component code.

DSM enables significant improvements in the productivity of the software development process and the quality of the resulting products. Industrial experiences of DSM consistently show it to be 5-10 times faster than current practices, including current UML based implementations of Model Drive Architecture (MDA). Since experienced technical experts specify the code generators and components, the resulting code is better than that most developers write by hand (DSM forum). Significant improvements can be achieved, mostly because the complexity is limited by focusing on a single, well defined problem domain (Tolvanen, 2004).

3 Peer Assessment

Peer assessment is a process consisting of various cognitive activities such as reviewing, summarizing, clarifying, providing feedback, diagnosing errors, and identifying missing knowledge or deviations (Van Lehn et al., 1995). In literatures many peer assessment process models are described (Liu et al., 2001; Sluijsmans, 2002; Sitthiworachart and Joy, 2003; Volder, et al, 2007). Typically a peer assessment process can be divided into three separate stages. In stage 1, candidates complete their assignments and then submit assignment outcomes. In stage 2, each reviewer assesses peer assignment outcomes and then gives feedback. In stage 3, each candidate reads and evaluates the received feedback and they may improve their original assignment outcomes based on peer feedback. Note that various forms of peer assessment are available in practice. For example, stage 2 and stage 3 may be repeated for several rounds until the final version of the assignment outcome is produced. The assignments and assessment form should be either pre-defined or designed before the stage 1 (called stage 0).

Table 1: A typology of peer assessment in higher education (Topping 1998)

No.	Variable	Range of Variation
1	Curriculum area/subject	All
2	Objectives	Of staff and/or students? Time saving or cognitive/affective gains?
3	Focus	Quantitative/summative or qualitative/formative or both?
4	Product/output	Tests/marks/grades or writing or oral presentations or other skilled behaviors?
5	Relation to staff assessment	Substitutional or supplementary?
6	Official weight	Contributing to assessee final official grade or not?
7	Directionality	One-way, reciprocal, mutual?
8	Privacy	Anonymous/confidential/public?
9	Contact	Distance or face to face?
10	Year	Same or cross year of study?
11	Ability	Same or cross ability?
12	Constellation Assessors	Individuals or pairs or groups?
13	Constellation Assessed	Individuals or pairs or groups?
14	Place	In/out of class?
15	Time	Class time/free time/informally?
16	Requirement	Compulsory or voluntary for assessors/ees?
17	Reward	Course credit or other incentives or reinforcement for participation?

In addition, the variables of the peer assessment could include levels of time on task, engagement, and practice, coupled with a greater sense of accountability and responsibility (Topping, et al. 2000). Topping (1998) developed a typology, as shown in Table 1, which consists of a survey of variables found in reported systems of peer assessment in higher education.

4　Peer Assessment Modelling Language

Definition of a peer assessment modelling language can start from choosing the terminologies used in the domain of peer assessment. Such terminologies provide natural concepts that describe peer assessment in ways that practitioners already understand. They do not think of solutions in coding terms. Starting from the existing vocabulary also means that there is no need to introduce a new, unfamiliar set of terms, or create a mapping between two sets of terms.
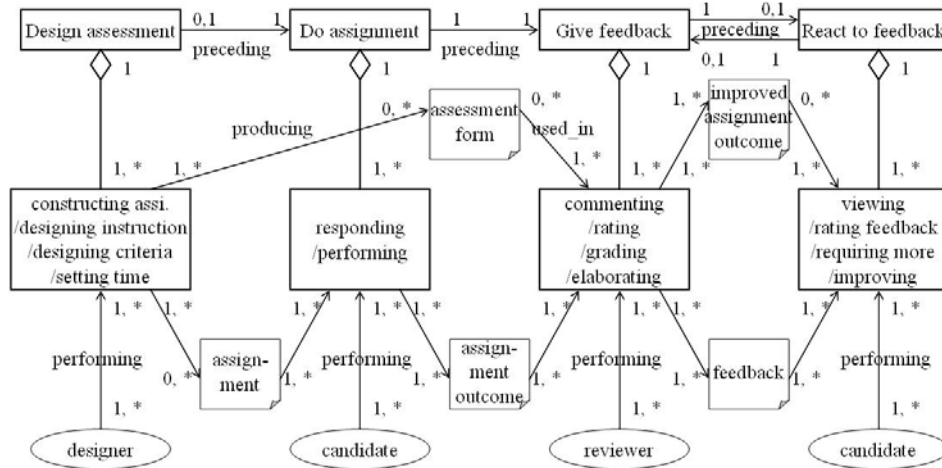
Figure 2: The meta-model of peer assessment

Based on the peer assessment process models and the typology described in the last section, we develop a meta-model by deriving many of the modeling concepts and the constraints. As shown in figure 2, a peer assessment process consists of four stages: *design assessment, do assignment, give feedback,* and *react to feedback.* In a *design assessment* stage, there is one or more various activities such as *constructing assignment, designing assignment/feedback instruction, designing assessment criteria,* and *setting time*. A *designer* can perform one or more activities and one activity can be done by one or more *designers*. One or more design activities may or may not produce *assignments/assessment forms*. Note that the *design assessment* stage may or may not be included in a peer assessment, because sometimes the *assignment* and the *assessment form* are pre-defined before a peer assessment starts. If the *design assessment* stage is included, it must precede a *do assignment* stage. In the *do assignment* stage, one or more

candidates may be engaged one or more activities such as *responding question(naire)* or *performing tasks* according to the *assignment*. The *assignment outcomes* will be distributed to the activities in a succeeding *give feedback* stage, in which one or more *reviewers* will assess the allocated *assignment outcomes* according to the *feedback instruction* and *assessment criteria* by providing *feedback* in forms of *comments, rates, grades*, and so on. In certain *summative assessment*, the process may terminate here. Normally, a *react to feedback* stage will follow, in which the *candidate* will *view* the received *feedback*. Sometimes, a peer assessment process can be design in ways that *candidates* can *improve* their own *assignment outcomes* and even ask reviewers to *elaborate feedback* and/or to *review* the *improved assignment outcome*, In certain extreme situations, additional *react to feedback* stages and *give feedback stages* can be repeated for many rounds.

Such a meta-model can be used as a modeling language to specify various peer assessment scenarios. It is important to note that this diagram just illustrates the first-class concepts of the meta-model and primary relationships between them. Many details of the modeling language are represented as alternatives, constraints, and rules, which can not be illustrated in the diagram. When modeling a peer assessment scenario, one has to describe the scenario by representing the design decisions in the modeling language. For example, how many participants will be engaged and what roles they will play; which kinds of assignments (e.g., an essay or a list of multiple-choice questions) will be used and whether each candidate has a different assignment or the same one; whether each reviewer can review only one or more assignment outcomes of their peers; whether assignment outcomes will be distributed in a rotated, reciprocal, or mutual manner. In order to help practitioners to make design decisions, the modeling language defines default values for certain design variables. For example, all candidates are reviewers as well. In addition, certain design decisions are related in a way if one design decision has been made then the relevant decisions will be made accordingly. For example, if a summative assessment is selected as the purpose of a peer assessment, then the activity *improving assignment outcome* in *react to feedback* stage and the activity *elaborating feedback* in *give feedback* stage will be excluded accordingly. Thus, it is necessary to guide practitioners specifying a peer assessment by employing a sequence of decision-makings. All of these decisions could be easily captured and recorded by using the meta-model, and thus made available for subsequent use and refinement in the process of modeling. Because of the limitation of the space, these issues will be not discussed in detail in this paper.

5 Discussion

In order to support practitioners to develop online peer assessment using the peer assessment modeling language, the things below should be provided: an authoring tool for modeling with the peer assessment modeling language, a domain-specific component library, and a domain-specific code generator. This section discuss these issues.

An authoring tool: A tool should enable practitioners to specify a peer assessment, as mentioned above, by guiding practitioners to make a series of decisions. On the one hand, the tool makes it possible that practitioners don't need to specify every detail by

employing default values and relevant decisions. On the other hand, the tool makes it possible that practitioners can specify any detail if they like.

A domain-specific component library: Because LD and QTI are executable code, LD components (e.g., activity and role) and QTI component (e.g., choice interaction and response-handling) can be regarded as basic components. More complicated components like certain templates represented as a fragment of LD/QTI code can be defined and stored in a library (Miao, Burgos, et al. 2007).

A domain-specific code generator: In our case, the code generator just generates LD and QTI code. Because the functions to generate LD code have implemented in LD authoring tools like RELOAD (RELOAD) and COSMOS (Miao, 2005), we just need to develop mapping functions to translate peer assessment modeling language into LD concepts. For example, a *stage* maps to the *act*, a *commenting* maps to an *activity*, and a *reviewer* maps to a *role*.

After these facilities are developed, practitioners should be able to develop and customize a peer assessment as a high-level model, which will be transformed into a corresponding LD+QTI model. The later model can be executed in any LD+QTI compliant run-time environment. It is important to note that DSM can be applied to support the development of other pedagogical models such as problem-based learning and 360 degree feedback.

6   Conclusions

In this paper, we outline an approach to apply the domain-specific modelling paradigm to the development of peer assessment. We developed a peer assessment modeling language and proposed to support the modeling process as a sequence of design decision-makings. Based on the peer assessment modeling language and the decision sequence, we will implement an authoring tool, associated component library and mapping functions in the near future.

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Requirements for Flexible Learner Monitoring

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Abstract: This paper analyses the requirements for the sensor and the semantic layer with regard to the scenario in which the prototype is applied. In particular, the requirements address one problem with open online communities: community members can switch communication services and channels while they participate and contribute to the community. This raises special challenges to learner monitoring. The paper discusses the functional requirements for learner monitoring with regard to these challenges.

Keywords: personal data, learner profiling, activity monitoring

1 Introduction

When performing a task, actors need various types of information in order to monitor the progress of the task. The basis for this information is provided by what we call *indicators.* Indicators provide a simplified representation of the state of a complex system that can be understood without much training. Furthermore, they help to focus on relevant information when it is needed, while the actors don't have to bother about this information most of the time.

Actors depend on indicators in order to organise, orientate and navigate through complex environments by utilising contextual information (Butler & Winne, 1995; Weber, 2003). Contextual information on the learning process has been proven as important to support the learning process. It stimulates the learners' engagement in and commitment to collaborating processes (Beenen et al., 2004; Ling et al., 2005; Rashid et al., 2006); it helps to raise awareness of and stimulates reflection about acquired competences (Kreijns, 2004; Kreijns & Kirschner, 2002); and it supports thoughtful behaviour in navigation and on learning paths (Van Nimwegen, Van Oostendorp, Burgos, & Koper, 2006).

It has been argued that indicators are part of the interaction process between learners and learning environments (Glahn, Specht, & Koper, 2007). As such, indicators depend on information about previous learning activities and their contexts. The information processing from monitoring learners to responding back to them can be modelled in four layers: a sensor layer, a semantic layer, a control layer, and a presentation layer. This layered architecture has been implemented as a preliminary prototype that uses indicators for supporting learner engagement in open online communities.

This paper analyses the requirements for the sensor and the semantic layer with regard to the scenario in which the prototype is applied. In particular, the requirements

address one problem with open online communities: community members can switch communication services and channels while they participate and contribute to the community. This raises special challenges to learner monitoring. The paper discusses the functional requirements for learner monitoring with regard to these challenges.

2   Experimental Scenario

The prototype integrates indicators into a community system. This system combines the community member's web-logs, del.icio.us[1] link lists and tag clouds. The indicator provides information on the interest and the activity to the learners. It contains two core components: An interest tag cloud and an overall activity chart. To maintain these indicators the system tracks selection activities, tagging activities, and contributions. The system adapts the presented information according to a learner's activity and interest level: It provides richer information the more a learner contributes to the community. Therefore, new participants will have different information indicated than those who contribute regularly to the community.

The community system acknowledges that its participants might already use a web-log or del.icio.us instead of offering similar services. However, it is not a requirement for participation to have both. When learners register for being "members", they can provide a URL to a feed address of their web-log and their nick-name on del.icio.us. This *personal data* is later used for creating a *learner profile.* Therefore, the community system provides only a portal to recent contributions, while the actual content is external to the system.

Each action within the system is considered as a learning activity and learners score "learning points" with each action they perform in order to indicate their learning progress. However, some actions require more effort than others. For example, accessing content provided by other users is easier to perform than contributing content through a web-log. Because of these differences, the actions have different scores.

The indicator system of the prototype is based on immediate and delayed interaction monitoring. Immediate monitoring is implemented only for selections (so called click-through), through which the system gathers information about requests of web-log entries or links from the link list. Data about contributions is accumulated from RSS2[2] or ATOM[3] feeds independent from a learner's actions on the user interface. Information on the collected links and associated comments is gathered through del.icio.us' RPC interface[4]. The tagging activities are extracted from the data on tag clouds that is provided from both the link lists and the learner's web-logs. A learner tags an external link or a web-log entry if a tag is added to the contribution.

The semantic layer of the prototype provides two aggregators: an activity aggregator and an interest aggregator. The semantic layer analyses the sensor data according to a definition given by the aggregators. Different to the sensor layer, the semantic layer is not limited to organising incoming sensor data, but it uses the aggregators to *transform* the sensor data into meaningful information.

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[1] http://del.icio.us

[2] http://blogs.law.harvard.edu/tech/rss

[3] http://tools.ietf.org/html/rfc4287

[4] http://del.icio.us/help/json/

The control layer defines how the indicators adapt to the learner's behaviour. The prototype implements two elemental adaptation strategies. The first strategy aims at motivating learners to participate to the community's activities. The objective of the second strategy is to raise awareness on the personal interest profile and stimulate reflection on the learning process and the acquired competences. The prototype adapts the strategies according to a learner's participation to the community.

The purpose of the indicator layer is to integrate the values selected by the control layer into the user interface of the community system. The indicator layer provides different styles of displaying and selects an appropriate style for the incoming information (Figure 1 shows an example). Two graphical and one widget indicator are provided by the prototype. One graphical indicator is used during the first level of the control strategy. This indicator shows the amount of actions for the last seven days. A second control strategy uses a different graphical indicator. It displays the activity in comparison to the average community member. The maximum value of the scale used by this indicator is the most active community member. Finally, the indicator layer provides a tag cloud widget for displaying the interests of a learner. In principle this widget is a list of hyperlinks. The tag cloud indicates higher interest values for each topic through the font size of the related tags.
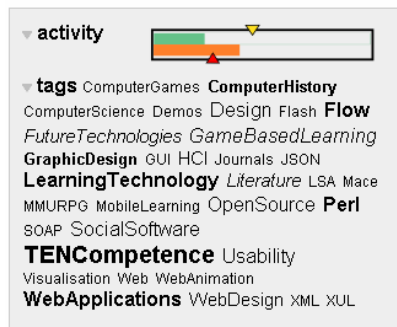
Figure 1. Indicator of the third level strategy

3   Meta-model

The purpose of the experiment is to analyse effects of activity indicators that adapt to the learner's progress. The hypothesis for the experiment is that adaptive activity indicators increase engagement in open communities in which learning goals and learning topics are not explicitly available.

Indicators are part of the interaction between a learner and a system, which is either a social system, such as a group of learners who are supported by a trainer, or a technical system like software for computer supported training. A single interaction is defined by two parts: an action performed by a learner and a response to this action from the system. With regard to learning, a learning process is described as a chain of interactions. These interactions have received some attention in research by focusing on the learner's cognitive processes (Butler & Winne, 1995; Garries, Ahlers, & Driskel, 2002). However, indicators are part of the interface of an external system. Following concepts of context

aware systems (Dey, 2000; Dey, Abowd, & Salber, 1999; Zimmermann, Specht, & Lorenz, 2005) interaction appears as a symmetrical process between an actor and a system that is interconnected by the system's interface (see Figure 2).

With regard to this model, two types of context have to be distinguished: action context and constructed context. Action context is defined by all factors that are present when an action is performed. Examples for such factors are the time of the action, the geographical location where it is performed, the number of concurrent tasks, or even the pulse frequency of the actor. These factors are directly observable through monitoring, but are not necessarily related to the action. Additionally, the constructed context defines higher level factors that affect a learner's action. Examples are the social role of the learner, the experience of a learner in the community, and the learner's performance. These factors are not directly accessible by observing the learner's action itself, but require semantic enrichment and assessment of a range of information.
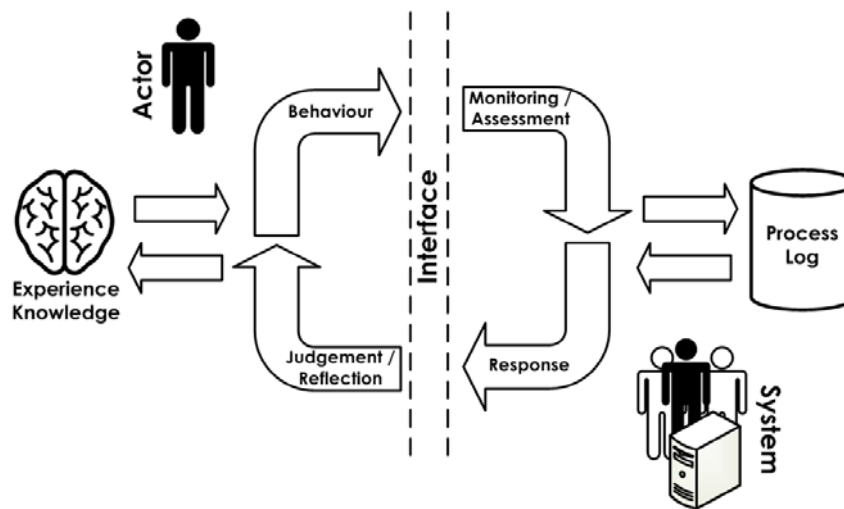
Figure 2. Learning interaction cycle

4   Functional requirements for learner monitoring

The prototype in applied by an open community in which the participants use different communication channels for their contributions. This raises a problem of learner monitoring: learners may perform learning actions that are not directly or immediately observable by the learning environment.

The prototype uses six sensors to monitor the actions of the community's participants:

- *Tagging sensor*, which traces the tags that a learner applied either to a link in del.icio.us or to an entry in a web-log.

- *Tag selection sensor* traces those tags that were selected from a tag cloud or a tag list of an entry in a web-log.

- *Tag tracing sensor*, this sensor traces the tags that are assigned to web-log entries or del.icio.us links when a learner visits this entry.

- *Entry selection sensor* that reports the hyperlinks a learner has accessed.

- *Entry contribution sensor*, which traces the contributions of a learner to the community.

- *Access time sensor*, this sensor traces the time of an interaction.

The sensor layer has to be aware of delayed observations. Only the *tag tracing sensor,* the *tag selection sensor* and the *entry selection sensor* are directly observable by the community system, because they can be part of the user interface. For the other sensors, synchronous learner monitoring of contributions is not possible for performance and policy reasons. Therefore, the sensor layer has to assure that events can be entered to the system asynchronously.

The learners can specify in their personal data, the nick names they use for the del.icio.us social bookmarking service. The *tagging sensor* has to check for this data entry in order to select the appropriate information from the service. If a learner has not specified a nick name, the sensor must ignore this service for the given user.

Furthermore, learners can specify one feed URL to their web-logs. This URL is used by the *entry contribution sensor* to identify new contributions. The feed URL has to point to an RSS2 or to an ATOM feed-record. The entry contribution sensor has to access this URL frequently in order to identify a user's contributions to the community. These feeds also provide information to the *access time sensor* about the time when this contribution has been made. The *tagging sensor* has to analyse the tags that are used for the contributions sa they are available in the feed-record.

In the learner's profile the different sensors have to be distinguished, because the observed actions have different semantic meaning regarding the learner's performance and interests.

On the semantic layer the prototype implements two types of contexts: *learner activity* and *learner interest*. Both contexts are related either to the learner or to the community. Therefore, the semantic layer has to provide an interface that allows selecting each context either from the learners' or the community's perspective.

The learner's activity is given by the actions performed within a certain time frame. This can be seen either from an absolute or a relative perspective. The absolute activity refers to the number of actions a learner has performed, whereas relative activity puts the learning actions in relation to an external value. For the prototype the activity context has to provide the absolute activity, the types of actions that are involved, and the activity in relation to the best performing community member.

According to Claypool, Le, Wased, & Brown (2001) the interest context has two different forms: explicit interest and implicit interest. For the prototype, the interest of a learner is defined by the tags used. Explicit interest is given if learners use specific tags for their contributions. Implicit interest is defined by a learner's selection of tags or accessing content that has certain tags assigned. The semantic layer has to provide the learner's interest regarding a certain tag as two values that reflect the explicit and implicit interest of the learner.

5   Conclusions and further research

This paper discussed the functional requirements for learner monitoring in a prototype of a learning environment for open communities. These requirements define how learner editable data has to be used to select learner contributions that have been made through different communication channels or services in order to build up a learner profile. This profile is used to provide adaptive indicators that support the learners' engagement to a community. The requirements presented in this paper specify the preconditions that have to be met by the learner profile in order to enable adaptation to the learners' experiences by utilising contextual information. Further research will assess and extend these requirements towards a flexible system of context aware learner monitoring.

Acknowledgements

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LEARNING PATHS AND COMPETENCE FRAMEWORKS

Towards a practitioner-centred approach to the design of e-learning competence editors

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Abstract: This article reports on the background research on requirements and current approaches to editors for learning curriculum designers. First we take a critique look at the state of the art in the domain of learning activity editors. We then look back in the information visualization and interaction literature to discuss the design challenged of such tools. From these current theories and applied works we define a set a rules that are crucial for the design of CDP editors based developed on top of complex e-learning models. Finally, we exemplify the set of design rules with a prototype integrating tightly coupled map-based and Gantt chart views.

Keywords: e-learning, user-centred design, learning editors, competence development

1 Introduction

In our largely knowledge-based society there is a growing need for continuing professional development, in order to deal with the evolving character of professional knowledge and technologies. This leads to the creation of curricula that are not limited to formal learning activities that lead to certificates or degrees, but that also include non-formal learning activities. We define this collection of learning activities as Competence Development Programmes (CDPs) that are aimed at maintaining or increasing the level of a worker's competence are generally. In order to support these activities, a technological infrastructure is required for storing, organizing and sharing the various bodies of knowledge; in addition, this infrastructure should provide lifelong learners with learning objects that fit their individual background knowledge, learning objectives, and other needs. Technological support for learning activities is not a new concept; a substantial amount of research has been carried out in the field of adaptive and intelligent web-based educational systems (Brusilovsky and Peylo, 2003). However, the broader field of competence development poses several additional challenges and requirements such as the development of positioning, navigation and learning support services. Moreover, tool to support the practitioners who create and maintain CDPs must still be deployed. So far, very little work has be spent on transforming the complexity of learning path model (Koper and Tattersall, 2005) into usable tools for practitioners and learners. This paper proposes to move towards a practitioner-cantered approach to the design of e-

learning competence editors by first defining clear and intuitive guidelines to meet the challenges opened by the underlying complexity of e-learning models. Then, we present a prototype that will be used by curriculum designers for positioning their material and for creating tentative learning paths, as well as by curriculum planner (e.g. learner) for planning learning routes.

This article is structured as follow. First we describe previous works in the domain of learning management systems. We compare them with a list a set of requirements for the design of competence editors. Then, we provide a theoretical framework on the challenges in the design of interactive visualization system. From that we define a set of rules that we applied to the design of our prototypical competence development program editor. We believe that these rules can help the development of more user-centred tools for data-rich e-learning environments.

2   Related works

The domain of learning activity editors has been fruitful these past years. We reviewed 3 of the most compelling research works to understand their features and limitations. First, LAMS (Learning Activity Management System)[1] is a system for creating and managing sequences of Learning Activities. Its authoring tool allows teachers to create and modify sequences of learning activities and store these in the sequence repository), and monitoring (where a teacher can select a sequence from the sequence repository, assign a group of learners, activate the sequence for learners, and then monitor their progress). It features a very simple path creation without providing requirements in the relations. Moreover, it disposes to only a limited set of types of activities and resources in its toolkit.

Moodle[2] is a Course Management System (CMS) for producing web-based courses. In this platform, a teacher has full control over all settings for a course and its management. He/she has a disposable a flexible array of course activities such as forums, quizzes, glossaries, resources, choices, surveys, assignments, chats, workshops. The learning path is ordered according to the course format by week, by topic or a discussion-focused social format. The social aspect and simplicity of the platform made it very successful.

As part of the RELOAD project (Reload, 2005), Phillip Beauvoir and Paul Sharples of the University of Bolton have developed the Learning Design Editor. It supports the full IMS Learrning Design specifications for Levels A, B and C. In a project manager view, learning planners can organize their Learning Designs. This tool does not carry a very intuitive sense of creating learning path and sequencing activities. It is probably due to its purpose of staying at very close to the IMS-LD complex specifications.

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[1] http://www.lamsinternational.com/
[2] http://www.moodle.org/

3   Design challenges

The design and use of interactive information visualization tools such as e-learning editors have been widely studies in the past. As advised by (Schneiderrman et al, 2000) visual tools should be designed to be both displays and search tools at the same time. Some visual schemes generate only one view per information space, but allow the user to zoom in and out, rotate, or in general change his/her own viewpoint on the image resultant from the visualization. This approach to visualizing information spaces inhibits searching and browsing by making it difficult for users to isolate, identify, and analyze parts or aspects of the information space. Users should be allowed to customize and control the manner that the tool at hands addresses information spaces. Moreover, users should be able to specify which part of the information space to visualize in a dynamic manner, making browsing are re-querying information spaces a process of moving between different views and viewpoints at the same time. The latter approach is not only based on the fact that tools should allow free browsing, but also on the general need of users to identify relations within the information space and between information spaces as well. This engenders the necessity to represent a number of information spaces simultaneously within the same visualization or within a number of independent windows with tiling or any other design choice that developers might commit to answer this need. On the other hand, not all information spaces are complete or closed sets, some of them remain open or dynamic while others suffer from non-rectifiable gaps. Gaps in information spaces should be visualized and made noticeable for the users in order to ease their identification and isolation. Some visualization schemes have chosen to abstract such gaps in favor of the overall presentation or the look of the visual metaphor, but it's rather vital for the study of such gaps that the latter be visualized in relational context with the rest of the information space. Finding what is missing in the information space is as important as finding what is actually there.

4   Interaction design

The efficiency of tools directly derive from the ability of humans to assimilate them and work around them, with these applications and schemes tailored in respect to the human cognitive process and taking account of its limitations and powers designers can hope to maximize their utility. A visualization that overwhelms human sensors will only frustrate its users whom will become largely prompt to erroneous behaviour and discontinuity with the information's context. The failure to take human physiological properties into considerations may strongly be the explanation behind the failure of many complex information schemes to achieve high usability levels.

Interactive visual tools, like the majority of software applications, may be dependent on the human environment in which they are deployed. In some environment, users don't have the time to decipher complex information metaphors designed to represent large information spaces, while in others users may be totally dependent on their interaction with the information application to succeed in their work or quest. In short, understanding the properties of the targeted human environment and how humans behave psychologically in that environment becomes an issue of moderate if not high priority to

the designers of visualization schemes and to those developing software application in general. However, being a special type of software, informative applications are not generally built only to cover the users' need for a set of functionalities and are rarely developed to pertain to a closed set of tasks. These applications rather aim at making information spaces accessible and manipulative, and hence shed more importance on understanding the behaviour of users within and around the information spaces visualized. Therefore, formulating a good understanding of the users' behaviour around certain sets of information spaces facility the design of schemes that afford some beneficial actions and inhibit others.

5   Our approach

As discussed earlier, we are challenged to invent powerful information visualization methods, while offering smoother integration of technology with task. This section summarizes our prototype facing this difficult challenge in the context of e-learning. The literature and state of the art review on learning activity editors, information visualization and interaction design revealed the issues we intend to tackle in our prototype. In the context of this work we believe important to follow the information seeking mantra extended with a direct manipulation approach. In consequence, we set rules for visualization and interaction of a CDP editor (Table 1)

Table 1: Design rules

Visualization	
Integrated system	Essential tools and views in a single integrated frame to preserve spatial continuity
High interactivity	Immediate feedback for all actions to preserve temporal continuity and to encourage exploration
Different views	Emphasize different aspects and perspectives
Tightly linked views	Changes in one view are reflected in the others
Interaction	
Probing	View more details about a learning object and to get an understanding of the relationships between the different views.
Selecting	to mark objects that are of short-term interest

In consequence we developed a design approach to integrate these rules. We based our solution on the integration of tightly linked views using a map-based visualization and a Gantt chart. The former provides a spatial view on the position of a learner within a learning environment made of learning objects. The latter delivers a temporal view of the breakdown of a learning path in time.
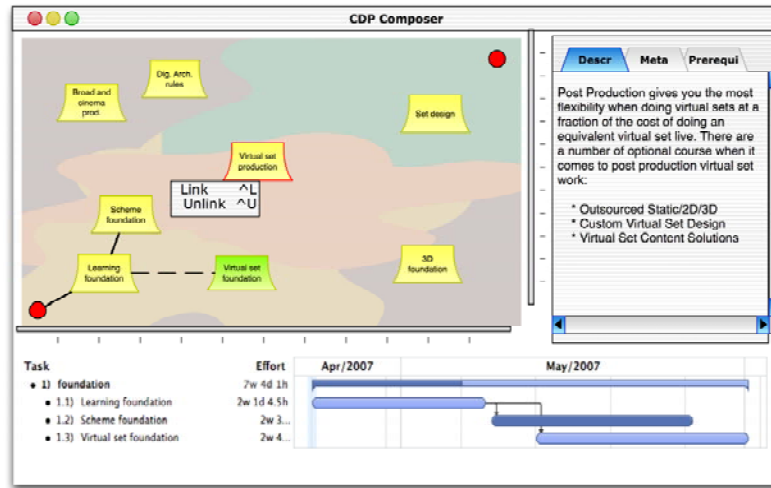
Figure 15: Screenshot of the prototype showing the integration of the tightly coupled map-based and Gantt chart

6 Map-based visualization

This first attempts lacked of strong metaphors to explore and navigation the information contained in a competence development program and a learning path. Therefore, we propose to use of the human sense of orientation to compose and manage Competence Development Programs. The proposition is to use the physical world (maps) metaphor for a learner to browse in a world of competences and learning object. The cities are replaced by learning objects (e.g. modules, courses, programs). The mountains, the roads and the rivers are here thematic and phases, which divide the learning object.

We believe that in two-dimensional information such as maps, users are trying to grasp adjacency or navigate paths, whereas in graph-structured information, users are trying to understand parent/child/sibling relationships. Moreover maps represent what a simple tree structure cannot show and they allow the navigation within the different level of granularity of information.

7 Gantt Chart

A 2-dimensional map does not well render the evolution over time of a CDP. In comparison, Gantt charts are visualization tools, understood by a wide audience, to control and administer activities to complete a project. Moreover, they help summarize the schedule of a learning path. For instance it allows revealing the dependencies between learning objects.

Therefore, we believe it could be well applied to CDP and follow our integrated systems and different views rules defined previously.

8   Conclusion

In summary, our approach uses a first 2D maps visual representation for content navigation and exploration and learning path edition. Second it the representation of the relations in time with the units of learning relies on a basic Gantt chart. The whole information visualization systems is integrated system with high interactivities (contextual on the maps). It uses a well-known metaphor of space to get detailed information on a selected item (unit of learning). Future work aims at evaluating the relevance of our approach with user experiments.

Acknowledgements

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Dependency Matrix and Duration in Time Based Composition of Learning Paths

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Abstract: Users of online infrastructures for life long learning face the task of developing long-term plans for their learning objectives. They plan by choosing among the pool of available Competence Development Programs (CDPs) those relevant to their learning ambition, divide them into learning steps, and arrange them sequentially in time. This task becomes progressively difficult as it stretches further with long term learning goals. In this paper, we provide a foundation for developing interactive information visualization tools that help the learner design a learning path based on personal preferences.

Keywords: Lifelong Learning, Semantic distance, representative dependency matrix, learning path description

1 Introduction

A learning path is an ordered set of CDPs that represents a viable plan for achieving a desired learning goal. The learning path determines when to start learning each CDP without violating the competence dependency relations among them. These relations are implicitly expressed in the competences associated with each CDP, whether being required or awarded. Given a set of CDPs related to a certain learning goal, we focus on finding possible learning paths and model the space created by this set.

Learners generally plan their paths in order to acquire the competences associated with their learning goals before engaging in learning activities. Moreover, they usually revise or update their paths based on their performances as they progress along their envisioned plans. In eLearning infrastructures such as TENCompetence (Koper, R. and Specht, M., 2007), learners might face the task of composing learning paths from large collections of CDPs upon defining their learning goals. This is generally true when planning long-term learning activities or far-set goals. Learners also seek to decompose these learning processes into steps or stages such as semesters in a masters degree in order to organize their learning paths.

Our aim hence becomes to develop methods for representing a set of CDPs whose borderlines are defined by the learner's own competences from one side, and the competences offered by the learning goal from the other. These methods compute the dependency relations among the CDPs in the set and identify potential learning paths. Furthermore, we explore ways to decompose the learning path into several steps based on

the learner's available time and dedication. We also measure the path's length based in the time requirements of each involved CDP.

2   Previous works

In general, matrices are handy whenever the relationships among a large set of elements needs to be analysed. Dependency matrices are frequently used in different scientific domains to represent constraint relations among elements of a set. A Dependency Structure Matrix or DSM is a matrix representation to model complex systems for design and engineering (Austin S., 2000). The DSM is also used for planning and/or managing projects where its analysis provides insight on activity flows and the effects induced by potential changes (Sangal, N., E. Jordan, et al., 2005). Dependency matrices are also used in semantic analysis to measure semantic distance between elements. Semantic proximity matrices enable vector representations of semantic spaces (Kandola, J. et al., 2003).

In the context of lifelong learning, flexibility and personalization are required in the process of designing learning paths composed from large sets of shared CDPs produced by different sources (Janssen, J et al., 2007). Both requirements are related with the prolonged learning process that stretch over years in circumstances that differ for each individual learner. Such need provides the direct motivation for developing a semantic infrastructure upon which learner support in terms of planning and visualization services can be provided.

3   Basic Scenario

In order to illustrate our proposal, we present a basic scenario based on the domain of digital cinema where 6 CDPs are made available for a degree on virtual sets production[1]. The structure of the curriculum composed from these CDPs is shown in figure 1. This figure exposes the dependency relations among the CDPs as well as the time required to achieve each of them. Given a cinema professional planning to acquaint herself with virtual sets production technologies, the task at hand becomes to arrange these CDPs in a learning path according to her personal preferences. The time that the learner can dedicate to the learning activities is considered to be around six hours weekly.

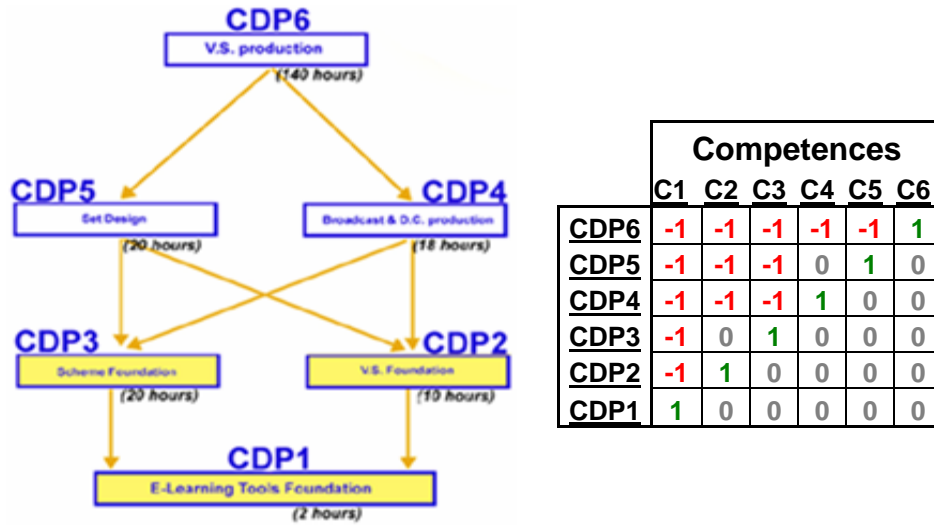[1] The IP-Racine project website http://www.ipracine.org/objectives/objectives.html

Figure 1: Virtual Sets curriculum (left) and the RDM of CDPs and Cs involved (right)

4 Representative Dependency Matrix (RDM)

The CDPs pool compiled in relevance to a learning goal G encompasses a competence set that generally contains intermediate and additional competences besides those inherent in G. Each CDP can hence be represented as a vector of the competence set where for each competence an associated value of **1** signifies that it is offered by this CDP, and a value of **–1** when it is a prerequisite of the CDP. A value of **0** signifies that the competence is unrelated or irrelevant to the CDP. We can now build a RDM where each row becomes the representative vector of a CDP. Note that prerequisite competences define a transitive relation where if CDP1 requires a competence C1 and CDP2 provides C1 but requires C2, then CDP1 requires C2 also. Figure 1 (right) shows an example of a RDM based on the scenario defined above.

The CDPs in figure 2 are sorted by dependency, meaning that the CDPs with larger prerequisite competence sets are found higher in the matrix. Notice that CDP1 does not have any prerequisite competence and can be considered the start of the learning path. The learning goal can also be represented in the matrix by a raw of (**-1**)s and (**0**)s and it can be placed on the top of the CDPs hierarchy. Such RDM poses a direct question on the existence of a learning path that joins any possible starting point with the goal sought. This problem is formally defined as Path Existence.

5 Path Existence

Let RCDP be the set of CDPs retrieved for a learning goal G with a set of involved competences C. Let A0 be the set of CDPs $\subset$ RCPD / for each $c \in$ C, A0(c) $\geq$ 0. A0 is

hence the set of CDPs that do not have prerequisite competences and offer a set of competences $C0 \subset C / \forall c \in C0, A0(c) = 1$.

Let $A1 = \text{step}(A0)$ be the set of CDPs $\subset$ RCPD / for each $c \in C0$, $A1(c) \le 0$. A1 represents the set of CDPs accessible from A0. We say that Path(A0, A1) = true if and only if $CR1 \ne \varnothing$, CR1 being the set of competences $\{\forall c \in C0 / A1(c) = -1\}$.

Path is a transitive relationship as previously explained. If Path(A,B) = true and Path(B,C) = true, then Path(A,C) = true. Hence we say that a goal G is attainable by RCDP if and only if $\exists A0 \ne \varnothing / \text{Path}(A0, G) = \text{true}$.

Given that the precedence relationships among the CDPs are respected, multiple paths are often possible to reach the goal. To tackle that, we developed an algorithm that find the first possible path, stores it and deletes it from the matrix, then searches for another one until all paths are found. Identifying multiple paths helps visualizing them for the learner to pick among them. However, such solution is not practical if the choices are numerous, especially in large-scale programs where hundreds of CDPs might be involved. For such cases, new methods should be developed.

6   Path steps and segmentation

Another problem that requires formal definition is that of automatically segmenting the learning path into phases or steps based on the dependency relationships that govern its inherent CDPs. A path in RCDP can be hence expressed by Path(A0, G) = true where the unitary steps in this relation define unitary competence-driven dependency steps.

$$A0 \rightarrow A1 \rightarrow A2 \ \ldots\ldots\ An \rightarrow G$$

Any segmentation of Path(A0, G) is a composition of these unitary steps that can be normalized by the factor of CDP duration. In this logic, the segments proposed for a learning path are more or less homogeneous in time after respecting dependency relations among the inherent CDPs.

7   Path length

The path length represents the effort or work required to reach a desirable learning goal. We measure such length by aggregating the hours a learner needs to spend on the activities inherent in the adopted path. If a path can be segmented into its unitary steps as previously argued, than the length covered by the path is the summation of the unitary steps' widths.

$$LENGTH(\ Path(A0, G)\ ) = \sum LENGTH(\ Path(Ai, Aj)\ ) = \sum TIME(Ai)$$

Based on our scenario, the learner can spend up to *6 hours* a week studying for the virtual set diploma. She can either finish CDP after CDP or commit to several at the same time. As shown in figure 1, the CDPs have different lengths in time and those represented with the same color can be taken simultaneously.

The following figure shows three combinations of the first three CDPs composed without breaking any precedence relationship. If plan A is followed, the learner will

finish a CDP before starting a new one. Two CDPs are taken at the same time in plan B, and plan C attempts to distribute time on all of the three courses.

In our scenario we assume that the learner is trying to plan as efficiently as possible by assigning all 6 hours of each week and avoiding having unassigned hours or gaps in time. Based on that, the learner plans the second phase of her LPD that covers CDP4 and CDP5, knowing that the first phase ends in on the sixth week with 4 hours to spare. Figure 2 shows two possible plans for the second phase, one asks to complete a CDP before starting another, while the other suggests taking both CDPs concurrently. Finally, CDP6 requires 140 hours to complete, and can only be taken after finishing CDP4&5.

Plan A — weeks 1-6

CDP1: E-Learning foundation	2					
CDP2: V.S. foundation	4	6				
CDP3: Scheme foundation			6	6	6	2

Plan A — weeks 7-13

CDP4: D.C. Production	4	6	6	2		
CDP5: Set design				4	6	6	4

Plan B — weeks 1-6

CDP1: E-Learning foundation	2					
CDP2: V.S. foundation	4	2	2	2		
CDP3: Scheme foundation		4	4	4	6	2

Plan B — weeks 7-13

CDP4: D.C. Production	2	3	3	3	3	3	1
CDP5: Set design	2	3	3	3	3	3	3

two different plans for CDP4&5

three different plans for CDP1,2,&3

Plan C — weeks 1-6

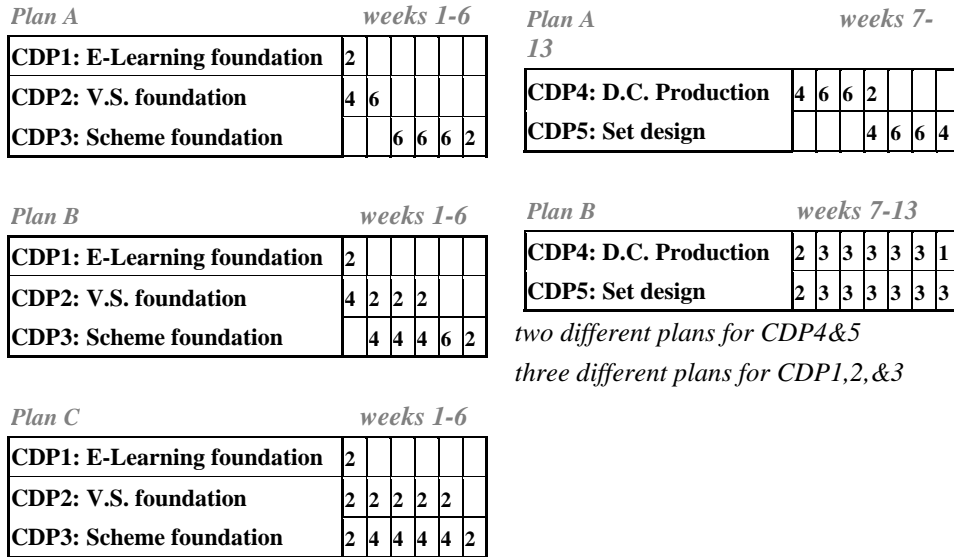|						
CDP1: E-Learning foundation	2					
CDP2: V.S. foundation	2	2	2	2	2	
CDP3: Scheme foundation	2	4	4	4	4	2

Figure 2: LPD planning

8 Conclusion and discussion

The methods and processes presented in this short paper form a foundation for developing information visualization tools that help learners plan their learning paths. We have been investigating relevant approaches such as Self Organizing Maps (H. Ritter and T. Kohonen, 1989) and map-based metaphors and evaluating their usability in the context of planning learning paths. Based on our current approach, the CDPs can be graphically represented by delegating the vertical axis of a graph to time duration and the horizontal axis to the spectrum of involved competences.

Acknowledgement

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