Stimulating Personal Development and Knowledge Sharing

INTERNATIONAL WORKSHOP

Stimulating Personal Development and Knowledge Sharing

PROCEEDINGS

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Workshop “Stimulating Personal Development and Knowledge Sharing”

Introduction

The fifth open workshop of the TENCompetence project took place in Sofia, Bulgaria, from 30th to 31st October 2008. These proceedings contain the papers that were accepted for publication by the Program Committee. This introduction presents the aims of the TENCompetence project, the objectives of the workshop, and the papers that are included in the proceedings.

The TENCompetence project

The EU 6th Framework Integrated Project TENCompetence aims to develop an European, open-source infrastructure that will support the lifelong development of competences. 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 this end TENCompetence is conducting RTD activities to further develop and integrate models and tools in four specific areas for the creation, storage and exchange of:

- knowledge resources,
- learning activities and units of learning,
- competence development programmes, and
- networks for lifelong competence development.

The consortium, that consists of 13 partners from 9 countries, conducts various large scale pilots. The project will disseminate its products widely and for free, will develop new business models for companies active in publishing, training provision, education, Human Resources Management (HRM) and technology support and will train associated partners, and especially SMEs, to deliver these services.

The TENCompetence infrastructure is aimed to provide a significant push towards further integration and collaboration in support of the European knowledge society. It can be used at all levels of learning: primary, secondary and tertiary education; continuing education, adult and company training and all forms of informal learning.

The goal of the workshop

The goal of the workshop was to identify and analyse current research and technologies in the fields that provide the building blocks for the development of an open source infrastructure that contains all the services needed to support individuals, teams and organisations to (further) develop their competences. This includes open, usable and accessible services for:

- Creation, sharing, discovery and use of knowledge resources, learning activities and learning paths by individuals, teams or organisations.
- Development, use, monitoring and maintenance of competence frameworks for different professions or domains of knowledge.
- Assessment of competences.
- Registration, use and sharing of personal data (profiles, portfolios, certificates).
- Discovery of suitable learning resources adapted to the user's needs and profile.
- Support of users to efficiently navigate through relevant learning resources to build specific competences.
- Support for users to learn in new fields and for the people providing the support (e.g. by providing monitoring services, email handling, etc.).

The papers

The papers were all reviewed by three reviewers from the programme committee. The best papers were invited to deliver an extended version of the paper for a special issue of the International Journal of Continuing Engineering Education and Life-Long Learning (IJCEELL) on the same topic (planned for 2009).

We organized the workshop papers into categories corresponding to the TENCompetence research areas, which resulted in the following clustering:

1. Web 2.0 knowledge resource sharing
- Providing social sharing functionalities in LearnWeb2.0
- A context-based methodology for the integration of Web 2.0 Services in learning scenarios
- Building a knowledge repository for life-long competence development
- A teacher education ontology for sharing digital resources across Europe
- Personal transparency and self-analytic tools for online habits
- A model for e-competence framework development in a university environment

2. Learning activities and units of learning
- The future of learning designs: making them useful and useable for teachers and learners
- Functional and non-functional requirements for building service-oriented assessment model
- E-portfolio assessment system architecture
- Using widgets to provide portable services for IMS Learning Design

3. Lifelong competence development
- Developing the personal competence manager evaluation work: 'EPIQ Business Demonstrator'
- Web-service architecture for tools supporting life-long e-learning platforms
- An Analysis of unreliability of competence information in learning networks and the first exploration of a Possible technical solution
- Effect of adaptive learning style scenarios on learning achievements
- A formal approach to adaptive content delivery

In conclusion

The papers in this proceedings provide valuable input for the TENCompetence project: they present the state-of-the-art in the fields related to lifelong competence development. We are just at the middle of our challenging project and we see this as a valuable result of our fifth open meeting.
As chairs of the programme committee and editors of these proceedings we want to extend our tanks to everybody involved in the process, especially to the members of the local organisation committee from the Sofia University "St. Kliment Ohridski", the authors and presenters and the members of the programme committee.

January 2009
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Providing Social Sharing Functionalities in LearnWeb2.0*

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Abstract

Within the TENCompetence project we are working on an open source infrastructure for the creation, storage and exchange of knowledge resources. We implemented LearnWeb2.0 (v.1) - a prototype, which in its current state provides appropriate functionalities for the aggregation and annotation of Web 2.0 resources for lifelong competence development activities. This paper focuses on the next steps planned, describing the main functionalities to be implemented in LearnWeb2.0 (v.2): resource selection, batch annotation and sharing as well as user notifications and sequencing, motivated by a real world knowledge sharing scenario.

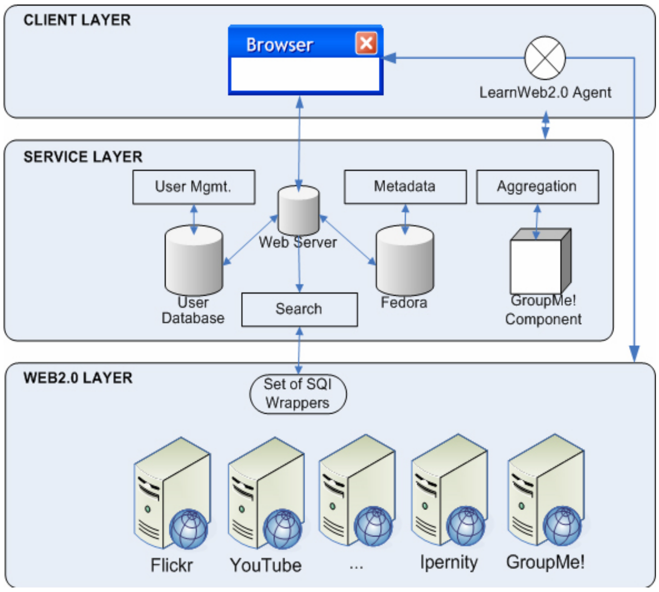

Figure 1: LearnWeb2.0 Architecture

1. Introduction

Web 2.0 is a challenging environment, in which knowledge resources are distributed among a set of heterogeneous online storage tools, each of which provides specific functionalities. On their desktop, people often bring together documents that share similar types, topics or proximity in time of creation [13][14], which can then be used by file management and search software to assist users in finding and aggregating resources relating to a common learning activity [6]. However, on the web, users are often forced to distribute related resources across different Web 2.0 applications according to the type of resource, e.g. pictures in *Flickr*, videos in *YouTube*, and bookmarks in *del.icio.us*, even though all these resources belong to one and the same learning context [8]. To integrate models and tools for the creation, storage and exchange of knowledge resources, we are implementing the *LearnWeb2.0* infrastructure [11], which makes Web 2.0 information accessible in ways that better support lifelong learning and knowledge sharing. Figure 1 depicts the architecture.

Whereas conventional Web 2.0 applications support a limited set of predefined tasks (such as storage, editing or discussing resources of specific types), our integrated *LearnWeb2.0* environment aims to provide a rich set of functionalities and a homogeneous overview over the entire distributed learning space, without unnecessary boundaries.

The *LearnWeb2.0(v.1)*[1] prototype provides the basic functionalities for the aggregation and annotation of Web 2.0 resources. Figure 2 shows the user interface of the *LearnWeb2.0*. In this paper, we analyze and describe new important functionalities that are necessary to automate time-consuming user actions, in order to make *LearnWeb2.0 (v.2)* more user friendly.

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*The work on this paper has been partially sponsored by the TENCompetence Integrated Project. Contract 027087.
[1] **http://phpcake.it.fmi.uni-sofia.bg/** LearnWeb2.0 prototype

Figure 2: LearnWeb2.0 User Interface

We will use a knowledge sharing scenario at the University of Pavia to identify the required infrastructure and user level functionalities in Section 2, followed by a more detailed discussion of the platform functionalities to be implemented in Section 3. In the rest of the paper we refer with *LearnWeb 2.0* to the version v.2.

2. Scenario "Knowledge Sharing at the University of Pavia"

We use a real scenario from the University of Pavia, focusing on ICT technicians working in the *Information Systems Area* at this University. The tasks performed by the technicians include the management of the ECDL[1] Test Centre and the organization of learning courses. So far, these have been provided by a private company and the technicians have supported them as online-tutors or examination providers. Recently a new task has been assigned to the group: the creation of two new e-learning courses related to ECDL materials (*Advanced Access* and *PowerPoint* courses). For these topics, many related materials are already available on the Internet, so we need to support proper organization of the work (searching for and organizing resources, as well as sharing them in the group) as well as detailed planning (implementation and delivery). The intention is to use *Moodle* as a platform to deliver the final content. Each technician will be responsible for a specific task: **Gabriele** will search for appropriate resources, **Daniela** will provide evaluation exercises, **Ivana** will organize the contents in keeping with the *AICA*[2] *Syllabus*. External contributions are also welcome: **Luigi**, who works on other tasks in Cremona, supports the group's work, monitoring partner activities.

In the following subsections we illustrate the course construction process focusing on three main aspects: *Searching for resources, sharing search results* and *aggregation and sequencing*, connecting our knowledge sharing scenario with the appropriate functionalities described in Section 3.

2.1 Searching for resources

As part of the task assigned to him, **Gabriele** will search for available materials, useful for the course. He registers at the *LearnWeb2.0* page and can now access the user management service of *LearnWeb2.0* and edit his preferences. He provides login data for his favorite Web 2.0 tools to allow for automatic single sign on to these applications. Because the *LearnWeb2.0* Agent is installed in his browser, **Gabriele** can identify important learning resources and group them together using the aggregation functionality, described in the section 3.4.

He starts searching on the Internet and on his desktop for interesting resources. He gathers MS Access Training[3] *PowerPoint* documents through *Slideshare*, video tutorials on Microsoft Access[4] through *YouTube*, links and bookmarks through his *del.icio.us* page using the filter masks, described in the section 3.1. He uses *LearnWeb2.0* resource upload functionality in order to upload new resources into a corresponding Web 2.0 tool and add them to the *LearnWeb2.0* platform at one stroke as described in the section 3.5. The resources can be aggregated together into a group. Such group

[1] **http://www.ecdl.it/** ECDL (European Computer Driving Licence)
[2] **http://www.aicanet.it/** AICA (Associazione Italiana per il Calcolo Automatico)
[3] **http://www.slideshare.net/caddo1975/ms-access-training-486265** Sheyahshe, M., Skaggs, M. © 2008
[4] **http://uk.youtube.com/watch?v=jED1vmaN_T0**

itself can be added to *LearnWeb2.0* as a resource.

As soon as **Gabriele** drags a resource or file (e.g. a podcast describing MS Office features[5]) into the *LearnWeb2.0* window, the Agent offers a selection of groups to which the resource or file can be added. Gabriele collects materials and bookmarks, using filter masks and annotation functionality described in the section 3.1. All resources can be accessed and shared on a collaborative basis by every *LearnWeb2.0* user and, in particular, the other team members. **Gabriele** can now create a new *Advanced Access* group and can drag the podcast into it.

2.2 Sharing research results

In the meantime **Daniela** looks for evaluation resources (e.g. Tests[6] and quizzes[7]) and uses *LearnWeb2.0* in a similar way. While looking for exercises, she also finds other useful materials on the web. Because *LearnWeb2.0* is a collaborative environment, **Daniela** can easily check to see whether **Gabriele** already found similar resources based on the query tags, as described in section 3.1. If not, she can decide to drop a short message into **Gabriele**'s browser using *SpreadCrumbs*, described in section 3.3. **Daniela** asks him to assess the item and to decide if it is worthwhile including it in the *Advanced Access* group.

Daniela browses through the search results and finds a group of related resources created by a colleague from a partner university who has already solved a similar task, and adds them to her *Assessment* group. She comments, tags and rates the resources. Finally, she shares the *Assessment* group with other ICT technicians in her university.

When a team member adds a new resource, the *LearnWeb2.0* Agent provides notification to all work group participants. **Gabriele** and **Daniela** both participate in the *Advanced Access* and *Assessment* groups. **Daniela** gets notified when **Gabriele** adds new contents and can search for exercises in order to provide appropriate assessment related to the topic indicated by the notification. Other ICT technicians, including those from other Universities, are interested in sharing resources and in contributing to the group. For example, **Daniela** can easily share all resources tagged with “Photoshop, filters” to all her friends that are working on a specific project which requires the use of a graphics program.

In this way, they can benefit from notifications arrived from a colleague at the University of Pavia, or from a partner university, who have already solved a similar task. For example, the University of Pavia has an annex in Cremona where the Faculty of Musicology is located. Students in Cremona also want to use the online course envisaged, so the technicians in Cremona are interested in providing resources as well. **Luigi** has previous experience in creating online courses. He accesses the *LearnWeb2.0* platform as an external guest, monitors the progress of the Pavia group’s work and can give them additional advice.

2.3 Aggregation and sequencing

Ivana is responsible for organizing the contents to be followed in the ECDL/ICDL Syllabus[8]. She bases this on the work done by the other colleagues, creating a *Syllabus* group and organizing contents according to the specific requirements of the learning course. She can access the *LearnWeb2.0* home page to get an overview over the various resource groups created so far. She can also add own related resources. **Ivana** can browse through the complete set of search results obtained so far, as well as look up the details of a particular resource. She can also comment, tag and rate resources using the annotation functionality, described in section 3.2. In the groups created by **Gabriele** and **Daniela**, she will find related resources which may be included in a learning module. For example, she is now in a position to include multimodal resources (e.g. animations) in a learning module,

[5] **http://whitepapers.zdnet.com/abstract.aspx?docid=178298**

[6] **http://www.ms-iq.com/TestStart.aspx?id=3**

[7] **http://www.docnmail.com/tests/computers/database/access.htm**

[8] **http://aicanet.net/certificazioni/ecdl/advanced-level/syllabus, www.ssru.ac.th/it/file.php/1/icdl_syllabus_v4.pdf**

possibly as a multimedia section in the course. **Ivana** aggregates the contents into a sequence using the *Learning Design Editor*. described in section 3.4.

3. LearnWeb2.0 Functionalities

As the above scenario shows, knowledge resources related to specific user activities can be aggregated into groups (e.g. learning courses, events). In the context of life-long competence development these groups are never complete, as knowledge resources appear, change and get outdated dynamically.

LearnWeb2.0 supports aggregation of knowledge resources as well as tagging and classification on the resource and group level. So far, however, all these activities have to be applied manually to every single resource, consuming valuable user time.

Motivated by our scenario, in the next *LearnWeb2.0* version we want to enable the user to specify the properties underlying the specific aggregation, classification, tagging or sharing decision, such that the system can perform event-driven group updates, e.g. automatically classify and share newly inserted knowledge resources.

In this section we describe the new functionalities corresponding to the requirements in our scenario described in the previous section, which will be available in the next *LearnWeb2.0* platform release, after appropriate discussion with all TENCompetence partners concerned.

3.1 Resource selection and sharing

A *LearnWeb2.0* user can select and share a set of resources based on a common property in order to support the search task of the Pavia team, as described on the section 2.1. Such property can be a tag, file type, timestamp and other properties or their combinations - a filter mask. A frequently used query mask can be stored as a *standing query* [5] in the user profile, enabling quick access to an up-to-date set of resources sharing the specified property as described in the section 2.2.

One further application of a *standing query* is to automatically share a suitable resource as soon as it is added to the repository and annotated.

LearnWeb2.0 supports collaborative search with automatic resource annotation. Once a resource in the search result list is selected, it is automatically tagged with the corresponding query terms. These tags can later on be used for resource recommendations to friends and colleagues.

The search function of *LearnWeb2.0* is not limited to a single Web 2.0 application, but integrates search results from a number of supported Web 2.0 sources. In the next release, *LearnWeb2.0* will provide user-specific search functionality to enable a homogenous integrated view on all knowledge resources stored at the various Web 2.0 accounts of the particular user.

This way the user will be able to place search queries limited to her distributed Web 2.0 virtual working space analogously to desktop search on a local machine.

3.2 Annotating search results

Manually adding new resources to *LearnWeb2.0* or updating metadata of existing knowledge resources is time consuming. Therefore the next release of *LearnWeb2.0* will provide selection and annotation functionality for a set of selected resources using a filter mask as described in the scenario section 2.1.

After selecting a set of knowledge resources, the user is forwarded to the editing page where she can perform metadata update on all selected resources at once. For example, the user can add new tags to the whole resource group, or assign all selected resources to a specific category as well as specify the time, location, language and access rights.

3.3 Bookmark sharing and notification

During web browsing the user might identify and annotate interesting webpages and notify partners and friends about these pages, as described in section 2.2. *LearnWeb2.0* will support this functionality using the tool *SpreadCrumbs* [4]. *SpreadCrumbs* enables users to create a sticky note on any web page, specifically addressed to one or several friends of the user. This note appears each time the recipient, a friend or a colleague of the user, enters the web page. Additionally, the user finds all notifications addressed to him in her *LearnWeb2.0* profile.

3.4 Resource aggregation and sequencing

The user may also be interested in aggregating a set of knowledge resources related to the same learning activity or competence as described in the content aggregation and sequencing scenario in Section 2.3. *LearnWeb2.0* uses the Web 2.0 tool *GroupMe!*[1] for resource aggregation. Currently only manual resource grouping is supported. In the next release we want to support grouping based on a filter mask.

Furthermore a *standing query* will enable automatic instant updates of the group with new suitable resources as soon as they are added to the *LearnWeb2.0* system.

LearnWeb2.0 provides web services which export its functionality to third party applications. This allows us to provide the *LearnWeb2.0* services for any sequencing tool. In the TENCompetence environment resources are organized using the Learning Design Editor *ReCourse* [5].

3.5 Resource upload

LearnWeb2.0 is an integrated environment which supports upload of resources using a common user interface and storage of these resources in the distributed Web 2.0 virtual working space of the user. The Web is not the only source where the user can find resources related to a competence. Some useful resources might be located on the user's desktop or other devices like a camera. *LearnWeb2.0* provides a possibility to directly upload the resource from the desktop or an external source to a suitable Web 2.0 tool and to annotate it as described in scenario section 2.1.

In order to upload a resource, the user selects a file to be uploaded and the Web 2.0 target tool. *LearnWeb2.0* supports upload to Web 2.0 tools through the tool API. Upon upload, the user specifies an access policy to the resource (private or public) as well as further metadata and uploads the resource which afterwards appears in her user profile.

4. Related work

The authors of [16] have shown that Web 2.0 services stimulate active participation of learners and allow creating a sense of community in formal distance courses. *LearnWeb2.0* is aimed to support learners in informal learning settings. Pedagogical implications of using Web 2.0 tools in the competence development process need to be investigated in the future. In this paper we concentrate on information access and retrieval.

The majority of the available Web 2.0 applications is typically designed for a specific task like storage and management of videos or bookmarks. *Netvibes* or *iGoogle*, are examples of mashups which provide access to different Web 2.0 applications in a single environment, however these applications still remain separate [15]. *LearnWeb2.0* does not only integrate many of the applications which became well known to a broad bunch of the potential TENCompetence users, but it makes also possible to share the functionalities of those applications. Our aim is to bring together and manage resources in a fully integrated environment to help teaching and learning [7].

In such integrated environment the user can access and manage his resources regardless of the actual storage application. The need for assistance in (multiple, flexible) filing and searching facilities to offer enhanced attributes in users' desktops was identified in [6]. *LearnWeb2.0* enhances this concept into a virtual desktop, spread over a number of Web 2.0 tools.

Typically Web 2.0 applications do not go beyond the needs of individual users as "islands unto themselves", whereas TENCompetence addresses the desire that people have in wanting to share with others what they have found, relating to lifelong learning and competence development. One important contribution of *LearnWeb2.0* is the collaborative search component. Recent studies have shown that social search techniques might improve the effectiveness of the web search [2]. *SearchTogether* [12] is such an interface for collaborative search. In *LearnWeb2.0* we will go one step further and allow the system to store and reuse the most successful queries for competence development.

5. Conclusions

In this paper we used a real-world scenario to identify and discuss further challenges for integrating social software tools into our *LearnWeb2.0* infrastructure. We sketched the main required activities and described the most important functionalities, to be provided in the next *LearnWeb2.0* release.

Moving from manual resource aggregation and annotation, we will provide resource aggregation based on a automatic filter mask, and standing queries will enable instant updates of new resources.

In general, the first release of *LearnWeb2.0* has focused on interoperability. The functionalities in the next release will focus on community support and sharing in a Web 2.0 environment, moving the *LearnWeb2.0* environment more towards social network software. Examples include automatic notification along a friendship graph as well as further promotion of the internal communication among *LearnWeb2.0* users.

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A context-based methodology for the integration of Web 2.0 Services in Learning Scenarios

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Abstract

The emergence of the Web 2.0 technologies in the last years have changed the way people interact with knowledge. Services for cooperation and collaboration have placed the user in the center of a new knowledge building space. The development of new second generation learning environments can benefit from the potential of these Web2.0 services when applied to an educational context. We propose a methodology for designing learning environments that relates Web 2.0 services with the functional requirements of these environments. In particular, we concentrate on the design of the KRSM system to discuss the components of this methodology and its application.

Keywords: *Web 2.0 services, Knowledge Resource System Management (KRSM), Activity Context (AC), Knowledge Resource (KR)*

1. Introduction

The Web has now become a user-centered platform for managing and manipulating information. The newly emerging tools and services that allow users to create and share their own resources have changed the way that people interact and generated a new space for knowledge building based on users' collaboration and cooperation [1], [2]. Some studies propose methodologies and mechanisms to introduce several Web 2.0 services into education to enhance collaboration and facilitate content generation [3], [4], [5], [6], [7]. This diversity makes the conceptualization of a common integrated Web 2.0 platform covering the learner's necessities a complex task. In the framework of the TENCompetence European Project[1] a Knowledge Resource System Management (KRSM) is proposed as an accessible space for creating, discovering and sharing resources adapted to the learner's needs [13]. The KRSM defines a set of functional requirements that reflect these needs. It also specifies a set of usage activities by which the learners manipulate different Knowledge Resources [8].

The motivation behind this work is to select and adopt adequate Web 2.0 services that can be integrated into one platform that answers the KRSM functional requirements and supports its activities. In order to accomplish this task, we need an abstract interaction schema that defines the system components and their related functionalities. In addition, we require a selection mechanism that incorporates an evaluation criterion for assessing web2.0 services and identify the most adequate subset of services from the available pool.

This paper is structured as follows. In section 2 we describe the methodology followed throughout this paper. Next we identify and refine the KRSM interaction schema in section 3. Section 4 describes a Web 2.0 services' selection criteria and a proposal for its application. Finally, the main conclusions and future works are included in section 5.

2. System design methodology

We model the KRSM's interaction schema with abstractions that support a methodological evaluation of existing web2.0 services. We designate three different types of abstractions: activity context (AC), activity, and knowledge resource (KR). A context is prominent notion that surfaces across different academic domains, from psychology and cognitive science to HCI

[1] **http://www.tencompetence.org**

and system engineering. Akaishi et al. defines it as a modular representation of information under different perspectives in their description of a framework for context-based generation of information access spaces [14]. Same notion is repeated in the works of Theodorakis et al. who define context as a cognitive container which encapsulates a particular information view [15]. From an interaction design perspective, one context corresponds to one generic usage objective and encapsulates the interactive functionalities that correspond to this particular objective. These functionalities are articulated in the form of a series of activities, each defining a particular generic user action such as bookmarking or searching. Every context houses one or more information elements that the user manipulates by executing activities. The set of information treated in each context can represent one or more type of information elements such as videos, articles, or blog posts. We call these objects Knowledge Resources (KR).

The KRSM system serves several objectives dedicated to satisfying three major pedagogical needs: knowledge mining, transfer, and personalization. We hence intuitively define three ACs each dedicated to serving one pedagogical need, then divide the related functional requirements between these contexts. The resulting diagram presents an interaction schema that serves as the main reference in evaluating the relevance of each candidate web2.0 service. The functional requirements are traduced into activities, each added to its relevant AC. The KRs are then integrated into the schema, which is finally evaluated by tracing the action sequences of the KRSM use cases.

3. Identifying and refining the KRSM' activity contexts

We perform an analysis of the user educational needs in the KRSM scenario and derive a set of activities required to address them. On the other hand, the KRSM functional requirements are described through a set of activities referenced by "scenario activities" in the context of the TENCompetence project [8]. In order to assess the compatibility of different collections of Web2.0 services with these functional requirements, we infer a set of generic activities from a large group of previously indexed web2.0 service [12] and compare them to these "scenario activities". In total, 10 activities have been identified and are presented in Table 1. We call them primitive activities since they are generically supported by Web 2.0 services.

Table 1: Relating the domains' activities with the primitive activities obtained

Scenario activities	Primitive activities	Description of a situation
Search resources	Search/Find/ Explore	Search for familiar or new resources
Explore categories	Filter/Sort	User filters to sort available resources
Publish	Publish/Upload/ Share	Upload personalized resources to public system
Bookmark	Bookmark	Guard a reference to a specific resource of interest
Edit resource	Edit/Write/ Create	Create a new resource or edit an existing one
Rate resource	Rate	Associate an evaluative scaled rating to a given resource
Add tag	Tag	Label a resource with a representative concept(s)
Comment resource	Comment	Add comments to a resource
Download	Download	Guard interesting resources locally
Search per tags	Filter per tags	Use inherent tags to sort resources

Next, we cluster the activities described in Table I in three different ACs. We analyze the nature of each activity and group them according to the learner's usage objectives when performing them. For example, when a user downloads an image (download), he first has to search for it in a specialized image browser (search), select and sort the image provided by the browser and chose one (filter). Filter, search, and download are activities that a learner performs treating amounts of KR with a unique intention and in the same context: the Knowledge Mining AC. We repeat the same process with the rest of the activities and obtain two more clusters: The Knowledge Transfer, related with activities that contribute to the expansion of the collections of resources, and the Knowledge Personalization, that encompasses the activities that the user performs in order to organize and sort collected resources. Figure 1 shows the relation between the primitive activities and each of the AC.

Table I relates the primitive activities to the scenario activities of the KRMS system. The result is an initial schema with three ACs (Figure 2) where the learner manipulates different KRs through the primitive activities determined by the usage objective. We aim to provide the user with an environment in which passing through an activity to another should be a natural process. For this, we refine the first schema iteratively until having a model that avoids the overlaps over the different ACs. When the actions of the learner described in the usage profiles in [8] are traced over the schema (Figure 2), some overlaps between these ACs are revealed Hence, after iterating the schema and refining it we obtain three independent ACs (Figure 3) that enclose a set of primitive activities that corresponds to the actions associated with each of the specific educational needs described in the KRMS.

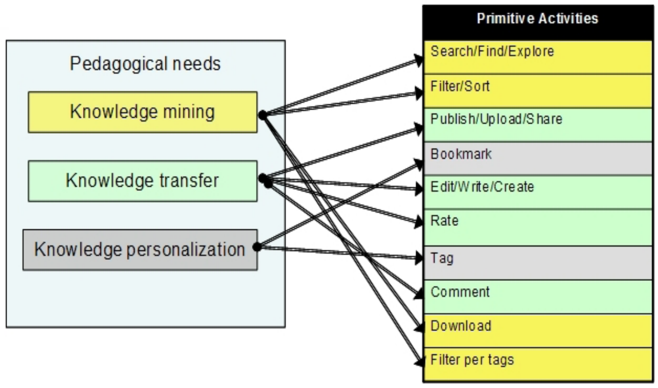

Figure 1: Mapping the educational domains behind the KRSM to the primitive activities in Web 2.0 services.

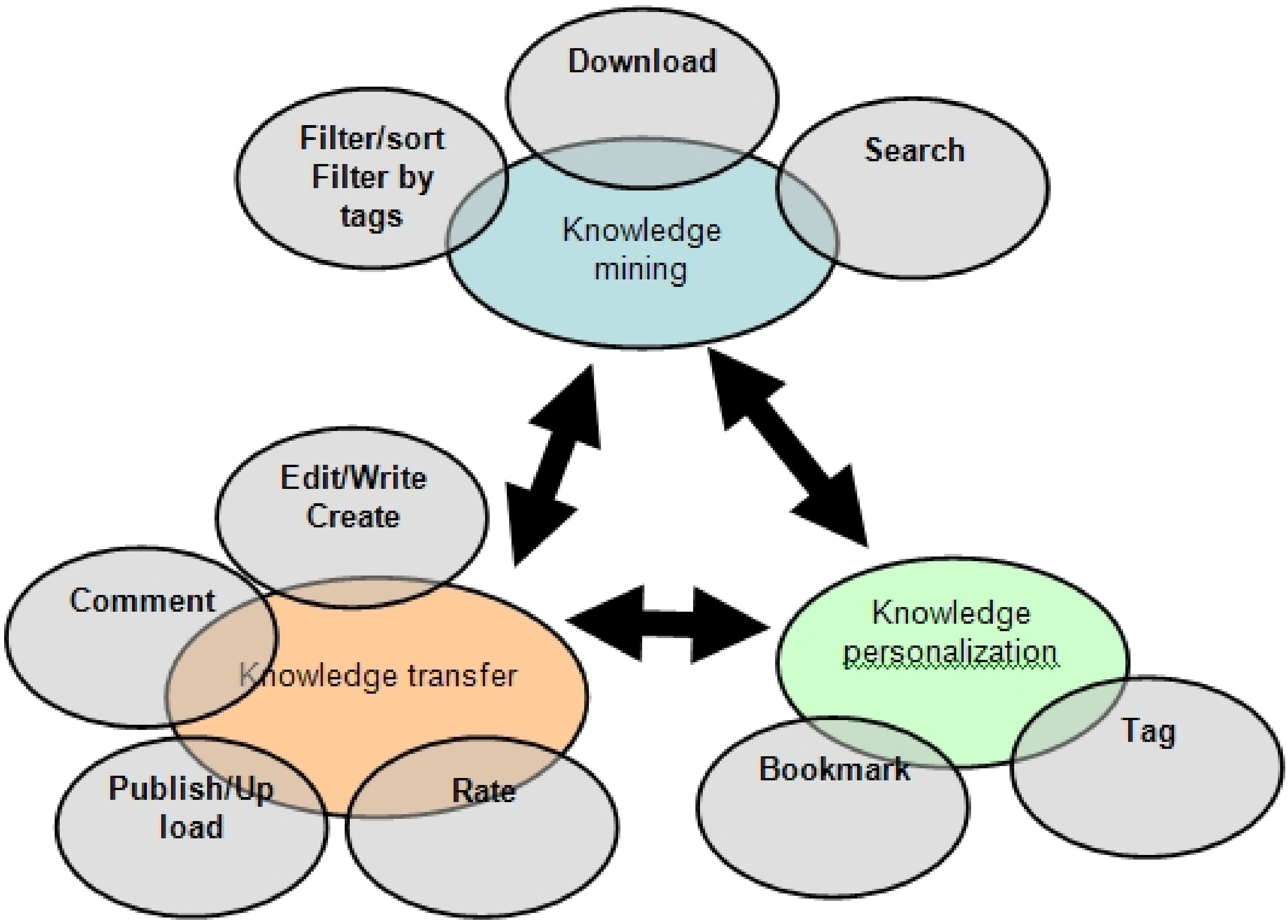

Figure 2: First schema of the mapping of the ACs with the primitive activities.

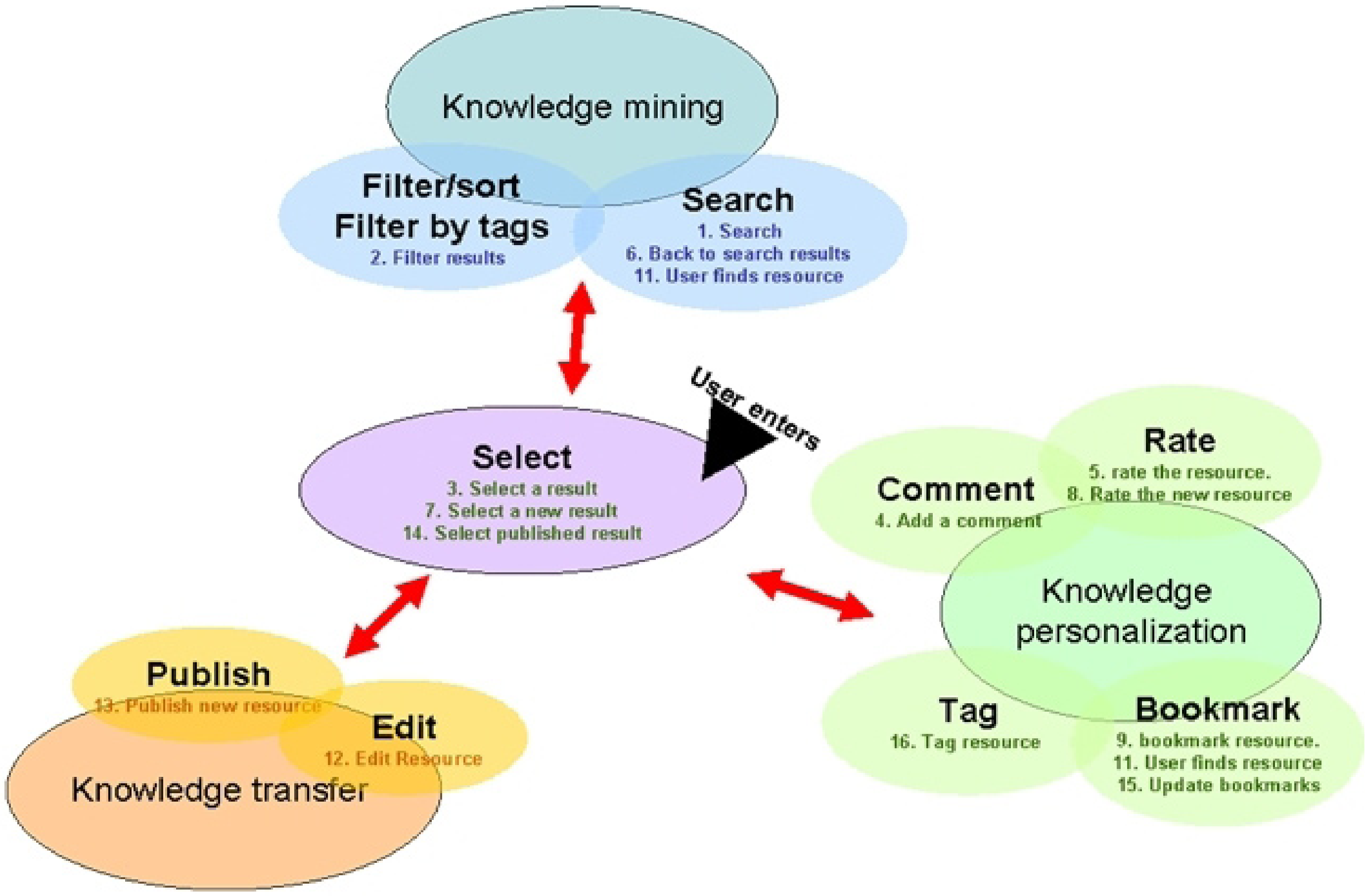

Figure 3: Final interaction schema.

4. Drawing a selection criterion

A list of Web 2.0 services with potential compatibility with the KRSM's functional requirements has been previously drawn [11]. In order to choose the right bundle of services from this list, we rely on contrasting these services against the KRSM model formed by the three ACs identified, along with their associated primitive activities. This association between the primitive activities and the usage objective allows us to determine the type of resources that are manipulated in each AC.

Since most of the Web 2.0 tools content are potentially related to the KRSM scenario, it becomes necessary to develop a selection mechanism that orders the services at hand according to their compatibility with the KRSM's model. First, the list is filtered according to set of conditions based on Nielsen [16] and Tognazzini's [17] best practices for system design. These conditions are the following:

- All services having functionalities that prove as incompatible with the design of the ACs and their schema should be disregarded.
- A service is selected if its functionalities cover the maximum number of primitive activities inherent in a specific AC.
- A service is selected if it handles all the types of KRs treated in this same context.
- The set of Web2.0 services selected for a given context should be minimized.

Second, we propose a set of selection steps for choosing those Web 2.0 tools that offer the best fit with the pedagogical needs represented by the KRSM scenario. Since the KRSM should provide a way to manage KRs using existing Web 2.0 services, we can either: (1) look for a Web 2.0 service for managing a concrete type of KR or (2) for one that offers functionalities to treat a specific set of primitive activities. We propose two ways of applying a selection criterion:

Activity-centered criterion:

- The service has to offer the functionalities to cover the selected primitive activity.
- The best service would be the one that covers the maximum number of KRs for the selected primitive activity.

- Follow steps 1 and 2 till you reach the constraint.

<u>KR-centered criterion</u>:

- The service has to cover the maximum number of technical requirements of the selected KR.
- The service would be that one that covers the maximum number of scenario activities which treat the selected KR.
- Follow steps 1 and 2 till you reach the constraint.

For example, Table 2 shows a list of services associated with the KRSM scenario. In order to select a set of services that answer the KRSM functional requirements, the available options have been mapped to primitive activities and compared. According to the selection criterion previously discussed, two services (Delicious and Drupal) represent the smallest set of services that covers all the functional requirements of the required system and treats all the inherent KRs types.

Services	Knowledge Mining		Knowledge Transfer		Knowledge Personalization			
	Filter /Sort	Search	Publish	Edit	Rate	Comm ent	Tag	Bookm ark
GroupMe		X					X	X
Flickr	X	X	X			X	X	
Delicious	X	X			X	X	X	X
Drupal	X	X	X	X	X	X	X	
Youtube	X	X	X		X	X	X	
Diigo						X	X	X

Table 2: Table of Web 2.0 tools and KRs applying the list of conditions.

5. Conclusion and discussion

In this paper we have discussed a methodology for the context-based modeling of learning environments, and the composition of such environments from proper selections of Web 2.0 services. The methodology was applied to the KRSM which was modeled in accordance with the primitive activities inherent in its functional requirements and the types of KRs treated. The identification of ACs helps in defining system components that can be mapped onto existing Web 2.0 services. This methodology allowed the rapid conceptualization and integration of a KRSM system called LearnWeb2.0. Our methodology is a preliminary approach that requires further testing and evaluation for its application in other scenarios. In the near future the methodology will be applied in other scenarios and evaluated accordingly. This includes the evaluation of the LearnWeb2.0 tool with real users that should conclude on the efficiency of composing learning systems from web2.0 services according to the methodology presented in this paper.

Acknoledgement

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Building a Knowledge Repository for Lifelong Competence Development

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Abstract

This paper focuses on building a knowledge repository for life-long competence development. It is an essential part of LearnWeb2.0 system designed for stimulating knowledge sharing, knowledge management and the conversion of information into knowledge. The paper discusses the system architecture, the choice of a digital repository, the modelling of digital objects and the metadata for resources.

1. Introduction

Within the TENCompetence project we are building an open source system *LearnWeb2.0* [5] for stimulating knowledge sharing, knowledge management and the conversion of information into knowledge into communities of practices.

Essential parts of the system are the knowledge repository and the KRSM (Knowledge Resource Sharing and Management) web services which allow access and management of the repository.

In this paper we discuss the following research questions/tasks regarding the building of the knowledge repository:

- design a multitier architecture for LearnWeb2.0 system;
- select a digital repository that best meets the requirements for life-long competence development;
- design and implement appropriate digital object models;
- design and implement web services for knowledge resource sharing and management that serve the needs of the TENCompetence project;
- use of metadata standards for describing resources.

2. Digital Repositories and Related Projects

One of the most popular digital repositories is DSpace [7]. Is was originally designed by developers at the MIT Libraries and HP Labs and currently is used by over 250 institutions. DSpace™ is a free, open source software platform for building repositories of digital assets, with a focus on simple access to these assets, as well as their long-term preservation [7]. It was originally designed with a particular service model in mind: that of institutional repositories of research material, and particularly research articles, which are produced by academic research institutions. A drawback of DSpace is that it uses a fixed web interface and cannot be easily integrated in other syustems.

Another example is the Knowledge Pool System ARIADNE [2]. It was an European educational digital library project initiated in 1996 by the European Commission's telematics for education and training program. It consist on a distributed digital library of education resources delivers reusable components to teachers and learners form different cultures and with different languages. The most innovative aspect of ARIADNE was its metadata. The new aspect that this project proposed was the semi-automatically generation of this metadata. Since the typical end user of this system was thought to be a teacher, this process should be simple and easy.

1 ***Fedora* is an acronym for Flexible Extensible Digital Object Repository Architecture [6]**

Another popular repository system is Fedora[1] - an open source, digital object repository system [6]. Using a standards-based, service-oriented architecture, the Fedora platform provides an extensible framework of service components to support features such as OIA-PMH, search engine integration, messaging, workflow, format conversion, bulk ingest, and others. In addition, features such as authentication, fine-grained access control, content versioning, replication, integrity checking, dynamic views of digital objects, and more are incorporated into the Fedora repository service [3, 4, 8].

Fedora has been adopted by hundreds of institutions for an array of innovative applications including open-access publishing, scholarly communication, e-science, digital libraries, archives, education, and more.

The RepoMMan Project [1] is developing a tool which will allow users to interact with a Fedora digital repository as part of their natural workflow. The University of Hull takes a broad view of repository function, seeing it as offering storage, access, management and preservation of a wide range of objects from conception to completion and possible publication. The effectiveness of a repository is linked to the quality of its metadata.

The University of Virginia Library is attempting to solve four problems with their Fedora implementation: management of complex objects that are organized in potentially multiple hierarchical structures; management of highly disparate data types and their preservation requirements; building virtual collections by recording and identifying relationships between objects in the repository; and the collection of born-digital faculty projects that incorporate new and reused materials into new scholarly contexts. Fedora was chosen because it was architected to facilitate handling of complex objects [9].

3. LearnWeb2.0 Architecture

A simplified scheme of the LearnWeb2.0 architecture is shown on figure 1. The main components of the systems are:

- LearnWeb2.0 Web Tool (written in PHP using CakePHP framework)- for interactively manage knowledge resources;
- KRSM Web Services (in Java) - for automatically manage knowledge resources;
- Fedora repository

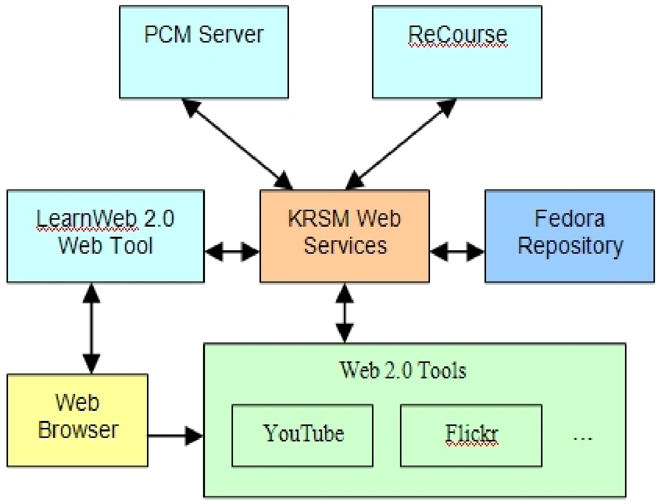

Figure 1: LearnWeb2.0 Architecture.

Other TenCompetence tools and servers (for example PCM Server, ReCourse, etc.) access the knowledge repository through the KRSM Web Services.

We have chosen Fedora as a basic repository platform because:

- Fedora supports flexible and extensible digital objects, which are containers for metadata, one or more representations of the content and relationships to other information resources.
- Fedora's digital objects provide building blocks to support uniform management and access to heterogeneous content including books, images, articles, datasets, multi-media, and more.
- Fedora is implemented as a set of web services that provide full programmatic management of digital objects as well and search and access to multiple representations of objects.
- Fedora is particularly well suited to exist in a broader web service framework and act as the foundation layer for a variety of multi-tiered systems, service-oriented architectures, and end-user applications.

The architectural view of Fedora digital object model is shown on Figure 2 [3].

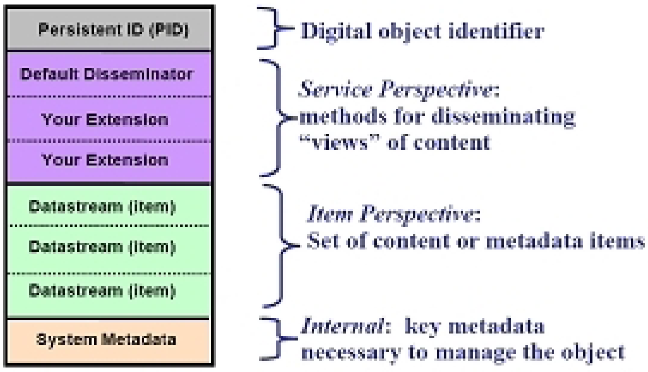

Figure 2: Fedora Digital Object Model.

Access to the digital object is provided by disseminators, which can simply deliver a desired portion of the digital object or can deliver a customized view. Fedora's digital objects are self-describing and self-delivering-key features that enable preservation.

4. Definition of Digital Object Models

We have identified and defined the following types of digital objects that are :

- *User* – a person who uses the system;
- *Category* – contains other categories and/or resource.;
- *Resource* – a resource stored on the server. Each resource has metadata in Dublin Core format [10] that describes the resource. The content of the resource can be stored on the server or anywhere on the Web (in this case the URL of the resource is stored on the server). Resources have tags, comments, popularity and rating.;
- *Tag and Tagging* – used for tagging resource.;
- *Comment* – for commenting resources. The comments can be rated by users.

The designed Fedora Digital Object Models and the relations between them are shown on Figure 3. Each object is represented as a digital object in Fedora with corresponding datastreams. The relations between the objects are represented and implemented by defining appropriate Fedora relationships. A number of methods are also defined for extracting information about the objects by creating several Behavior Definition Objects and Behavior Mechanism Objects.

Figure 4 shows an example of the Digital data model for resources.

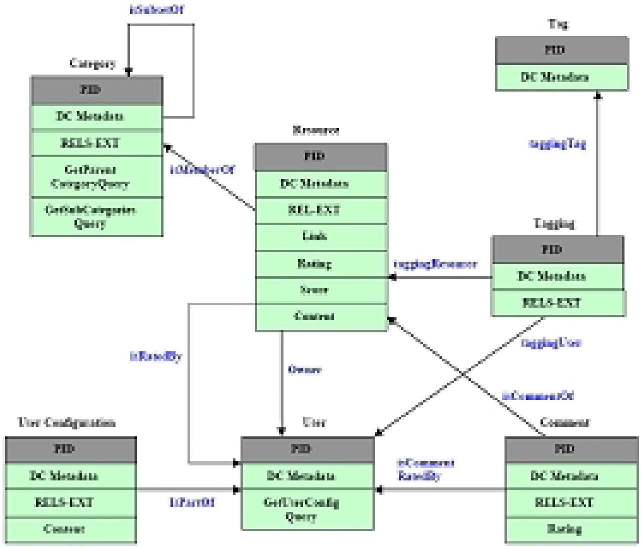

Figure 3: Digital Object Models with relations.

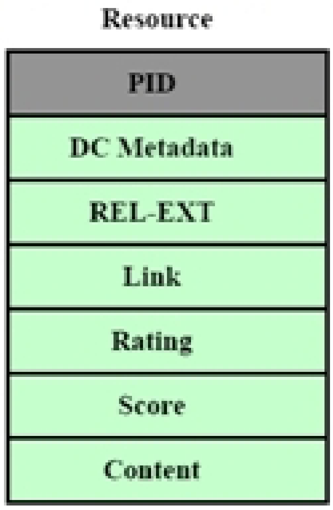

Figure 4: Digital Object Model for resources.

The resource has a PID (Persistent ID) and the following datastreams:

- DC - Dublin Core metadata;
- REL-EXT – containing the external relations of the resource with other digital object expressed in RDF;
- Link – containing the URL of a Web resource;
- Rating – containing the current rating of the resource;
- Score – containing the popularity of the resource;
- Content – for storing the content of the resource.

The following relations between the objects are defined:

- owner – between a resource and an user;
- isMemberOf – between a resource and category, stating that the resource belongs to the category;
- isSubsetOf – between categories and used to organize the categories in hierarchy;
- isCommentOf – between a comment and a resource;
- isRatedBy – between a resources and an user, stating that the user has rated the resource.
- etc.

Since the relations in Fedora are binary, for expressing the 3-nary relation that an user has rated a resource with a tag we have introduced a *Tagging* object that connects the user, the resource and the tag.

5. KRSM Web services

The KRSM Web Services are developed in Java and the APIs for the services are modelled using the REpresentational State Transfer (REST) approach. The implemented web services (currently 44) are divided into two groups:

- Access-API-Lite (27 services)
- Management-API-Lite (17 services).

The Access-API-Lite services are used for retrieving information and metadata about:

- Resources;
- Categories;
- Users;
- Tags;
- Ratings;
- Comments;
- etc.

These services also implement integrated search for resources in the Fedora repository and in Web 2.0 tools using the corresponding adapters (drivers).

The Management-API-Lite services are used for creation and modification of resources, users, categories, tags, etc.

The KRSM web services use XML for exchanging information. We have defined XML schema for each type of object stored in the repository. Figure 5 shows an example of the XML used for a resource.

The Web services are used intensively by LearnWeb2.0 web application. They can also be used for knowledge resource sharing and management by application developed within TEN-Competence project.

6. Resource Metadata

We have chosen to use the Dublin Core (DC) metadata standard to express the metadata for resources because:

- most of the knowledge resources used in the project can be fully described using DC;
- Fedora repository has full support of DC, automatically creates indexes on DC fields and supports search within DC fields;
- Fedora allows easily to extend the metadata with custom fields.

The DC standard defines a simple yet effective element set for describing a wide range of networked resources. The Dublin Core standard includes two levels: Simple and Qualified. LearnWeb2.0 uses the Simple Dublin Core which comprises fifteen elements.

LearnWeb2.0 uses resource metadata for searching/discovering resources and for proper view/manipulation of the resources.

We have designed and implemented a Metadata editor corresponding to the specific data model of LearnWeb2.0. The editor is a web based application written in PHP using the CakePHP framework. It uses the KRSM web services and is integrated in the LearnWeb2.0 web tool.

In LearnWeb2.0 the owner of the resource stored in the Fedora repository is responsible for supplying the metadata for the resource. Only the owner can use the Metadata editor to fill in the values of Dublin Core elements.

When the user adds a Web resource or uploads a resource to the repository she/he also has to provide metadata for the resource using the Metadata editor.

Dublin Core metadata is sufficient to describe most of the resources used within TENCompetence project. However, some types of resources, such as Learning Objects, Learning Designs, etc., need additional metadata usually described in the Learning Object Metadata standard (LOM). The next version of LearnWeb2.0 will be extended to support LOM for such types of resources.


```
<resource>
 <canonical>
  <link
href="http://www.oreillynet.com/pub/a/o
reilly/tim/news/2005/09/30/what-is-web-
20.html" source="Fedora" type="Web
resource" />
  <dc>
   <title>What Is Web 2.0</title>
   <description>A paper about Web
2.0</description>
   <identifier>resource:1</identifier>
   <creator>Tim O'Reilly</creator>
   <format>text/html</format>
   <subject>Web 2.0</subject>
   <type>HTML document</type>
   <date>06/10/2008</date>
   <language>English</language>
  </dc>
  <category>
   <link href="category:22"
type="category">category:22</link>
   <title>KRSM Category 2</title>
  </category>
  <owner>
   <link href="user:1022"
type="user">user:1022</link>
   <title>Ruud</title>
  </owner>
  <tag-list>
   <tag>
    <link href="tag:2"
type="tag">tag:2</link>
    <title>paper</title>
   </tag>
  </tag-list>
  <rating>
   <value>47</value>
   <numberOfVotes>15</numberOfVotes>
  </rating>
  <score>5</score>
  <comments>
   <count>4.0</count>
  </comments>
 </canonical>
</resource>
```


Figure 5: An example of the XML for a resource.

7. Conclusion and Future Work

In this paper we have discussed our approach for building a knowledge repository for storing, searching, accessing and retrieving knowledge resources for life-long learning within the TENCompetence project. We have selected Fedora as a basic platform for the repository and designed and implemented suitable digital data models. Also we have implemented web services for knowledge resource sharing and management. The repository and the services have been thoroughly tested and have proved their functionality. Some issues have been identified that are being solved for the next version.

We are planning to extend the described above digital object models to support user groups, LOM metadata, advanced search and to define improved access to the resources. The following types of resources will be supported:

- Public – the resources can be accessed by all users;
- Private – the resource can be accessed only by the owner;
- Shared – the resources is shared to a group of users.

Acknowledgement

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A Teacher Education Ontology for Sharing Digital Resources across Europe

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Abstract

Teacher Education (TE) is a dynamic, lifelong and lifewide learning process that is central to Europe's Lisbon Strategy ambitions. To fulfil these expectations, however, TE needs to embrace innovation more fully and assume a broader European perspective. The EC-funded Share.TEC project aims to help achieve this by providing enhanced, culturally-aware access to TE-related resources located across Europe. This is to be done via a federated resource brokerage system whose semantic core is the proposed Teacher Education Ontology (TEO). This paper describes the rationale for an ontology-driven approach, gives an overview of TEO's multi-layered structure for addressing multicultural and multilinguistic issues, and proposes the integration of top-down and bottom-up approaches.

Keywords: *Ontologies, Teacher Education, multiculturalism, multilingualism, metadata*

1. Introduction

As a dynamic, evolving process of lifelong and lifewide learning, Teacher Education (TE) has a crucial role to play in the development of Europe's knowledge society. To fulfil Lisbon Strategy objectives, however, TE needs to fully embrace innovation and, in the process, assume a broad European perspective. A number of serious obstacles are preventing this: TE is strongly rooted in linguistically and culturally bound national systems; the sense of community rarely stretches beyond the immediate locus; availability, use and sharing of digital resources are extremely patchy.

So far, efforts to bring ICT-based innovation to education systems have largely concentrated on the schooling end of the spectrum. Much less attention has been devoted at European level to supporting greater uptake within Initial Teacher Education (ITE) and Continuous Professional Development (CDP) processes. The EC-funded Share.TEC[1] project seeks to redress this by: building a federated aggregation of metadata describing TE-related digital resources located across Europe; providing personalised, culturally-aware brokerage services for retrieving pertinent content; fostering understanding and sharing of practices within the TE community Europe-wide.

The semantic core of the proposed system is a Teacher Education Ontology (TEO), an ambitious collaborative undertaking engaging Share.TEC partners and international experts. This paper describes the rationale for adopting an ontology-driven approach and provides an overview of both the semantic and structural dimensions of the ontology in its current state of development.

2. An ontology-based approach

TEO is aimed at capturing those aspects of the Teacher Education world that are relevant for sharing digital resources among Share.TEC users, a community chiefly comprising teacher educators, teachers engaged in ITE and CDP, publishers and content developers. TEO seeks to provide:

- pedagogical characterization of digital content;
- representation of user profiles and competencies;
- a foundation for multilingual and multicultural functionality;
- support for personalized interaction with

1 **Share.TEC - SHAring Digital REsources in the Teaching Education Community, eContentplus programme (ECP 2007 EDU 427015); www.sharetecproject.eu.**

adaptive user applications;
- support for the implementation of recommending functions.

The rationale for adopting an ontology-based approach in the Share.TEC system and platform is many-faceted. First and foremost is *sharing concepts amongst humans*. Potential users of Share.TEC come from a wide variety of contexts and backgrounds, and bring with them different perspectives and assumptions. Even when referring to ostensibly "common" concepts, they adopt different terminology, expressed in a variety of languages. The result can be highly confusing, with gaps, overlaps, mismatching and ambiguity. This seriously undermines efforts to gain *shared understanding* and leads to poor *communication* within the TE field across Europe. With this in mind, TEO is aimed at reducing conceptual and terminological confusion by identifying and properly defining a set of relevant concepts (and their relations) that characterize the TE domain in Europe. It will yield a non-ambiguous and consistent vocabulary to identify those concepts, and provide a framework for mapping culturally and linguistically diverse versions thereof (see Sections 3 and 4).

A further *raison d'être* of TEO's is to support adaptive user interfaces, applications and services that make use of *reasoning* techniques, thus allowing the implementation of inferential search engines, flexible representation of user profiles, and advanced ranking solutions. In this sense, TEO can both inform application design activities and support the definition of a common metadata model for digital educational resources.

In structural terms, TEO is organized in several separate but related branches that are self-consistent in nature:
- digital contents - educational resources and artefacts closely related to the concept of the "learning object" [9, 2];
- actors and roles in TE - the Share.TEC system's final users are represented as actors characterized by specific personal data, background, experience, preferences, etc. and by the history of their behaviour and interactions within the system [7, 5]. An actor can play different roles, such as teacher educator, student teacher, teacher, content developer, publisher, etc;
- competencies - specific, identifiable, definable and measurable knowledge, skill and/or other deployment-related characteristic which a human resource may possess and which is necessary for the performance of activity within a specific context [1]. Competencies are considered both at subject-matter level and transversally (personal behaviour or attitudes) [4]. Competencies will be used within the Share.TEC architecture to represent both user characteristics and attributes of digital contents [6];
- context - namely the various contexts of action within the domain of Teacher Education. It is in this branch that the ontology seeks to capture features of the organizations where Share.TEC users operate;
- knowledge areas - this provides a taxonomical representation of the TE knowledge domain, including pedagogical, technological and disciplinary aspects [8].

These branches draw on a mix of models that have been adopted and adapted specifically for describing the world of Teacher Education in Europe. A number of relationships span across branches, representing the links between different conceptual elements.

The top-down, ontology-driven approach adopted for capturing general knowledge will be integrated with a bottom-up contribution generated from user folksonomies and social tagging (see Figure 2). The two processes are distinct but complementary: users' social tagging will enrich the connotation of elements in the system, but without directly affecting the ontology's structure (at least not in the immediate term).

3. Multicultural and multilinguistic semantics

TE practitioners seeking digital resources outside their own immediate locus often find themselves (a) wading through endless streams of generic search engine results, or (b) dealing with repositories whose interface and metadata embody an often unfamiliar cultural model and are expressed in a language not their own.

To tackle this problem, TEO adopts a multi-layered structure (see Figure 1 below), with a common reference level that can be instantiated into a set of mutually exclusive, language-specific concrete ontologies. These gain specificity by being contextualized in a particular national educational system and culture. This multi-layer ontological hierarchy provides the framework for the definition of Share.TEC's metadata model. Like the ontology, the metadata model also comprises an upper reference level (Common Metadata Model) and a set of language/context specific derivations (Multicultural Metadata Model). Generating the network of relations between the common level and contextualised vocabularies is one of the measures that allow the specific semantic, linguistic and contextual differences (institutional, national, etc.) to be captured and reflected in the Share.TEC system.

This approach yields a number of potential advantages for users. Firstly, the system interface will be available in each partner language. Registered Share.TEC users will be associated with ontology-based profiles whose key concepts and relations are linguistically and culturally contextualised. Thus users will be able to search for contents from a range of different cultural and linguistic settings using their own language and referring to their own cultural model. Furthermore, inferential mechanisms will be developed to add flexibility to the search engines, allowing for example the retrieval and ranking of resources that do not exactly match the formal query of the user, but might actually satisfy their needs.

4. State of development and future perspectives

Currently in its first semester, the Share.TEC project is engaged in collaborative refinement of the common, culturally-independent layer of TEO, which is to be validated with the support of international experts. This will provide the basis for the subsequent development and mapping of the language and cultural specific derivations described above. This process should also lead to cyclical adjustment of the ontology and verification of its self-consistency.

Further contribution to this refinement process will also come from user folksonomies. As already mentioned, the top-down, ontology-driven approach adopted for capturing general knowledge will be integrated with a bottom-up contribution generated from user folksonomies and social tagging (see Figure 2).

As well as enhancing communication within the Share.TEC system, the folksonomies will offer a window on conceptual and terminological evolution in TE across Europe. This opens the way for bottom-up input in the ontology maturing process, diminishing the inherent risk of conceptual and terminological obsolescence often faced in ontology-driven approaches [3]. Share.TEC system users should therefore reap twofold benefits: greater shared understanding within the community, and more accurate fine-tuning of the system to their actual needs.

During development of both the semantic and technological layers of the system, a concerted effort will be made to engage with and build on existing knowledge and outcomes from related experiences and projects, especially those with a European dimension like TenCompetence[2], MELT[3], LRE[4] and Ariadne[5], which have tackled similar issues to those addressed in the Share.TEC project.

2 http://www.tencompetence.org/
3 http://info.melt-project.eu/ww/en/pub/melt_project/welcome.htm
4 http://lre.eun.org/
5 http://www.ariadne-eu.org/

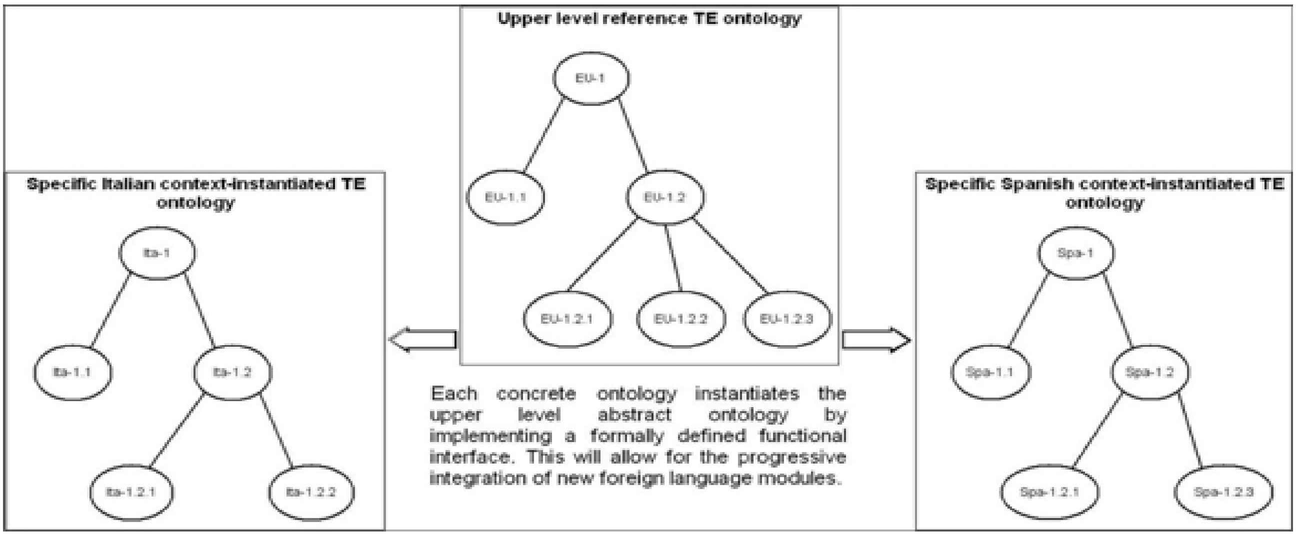

Figure 1: Multi-layer structure of TEO.

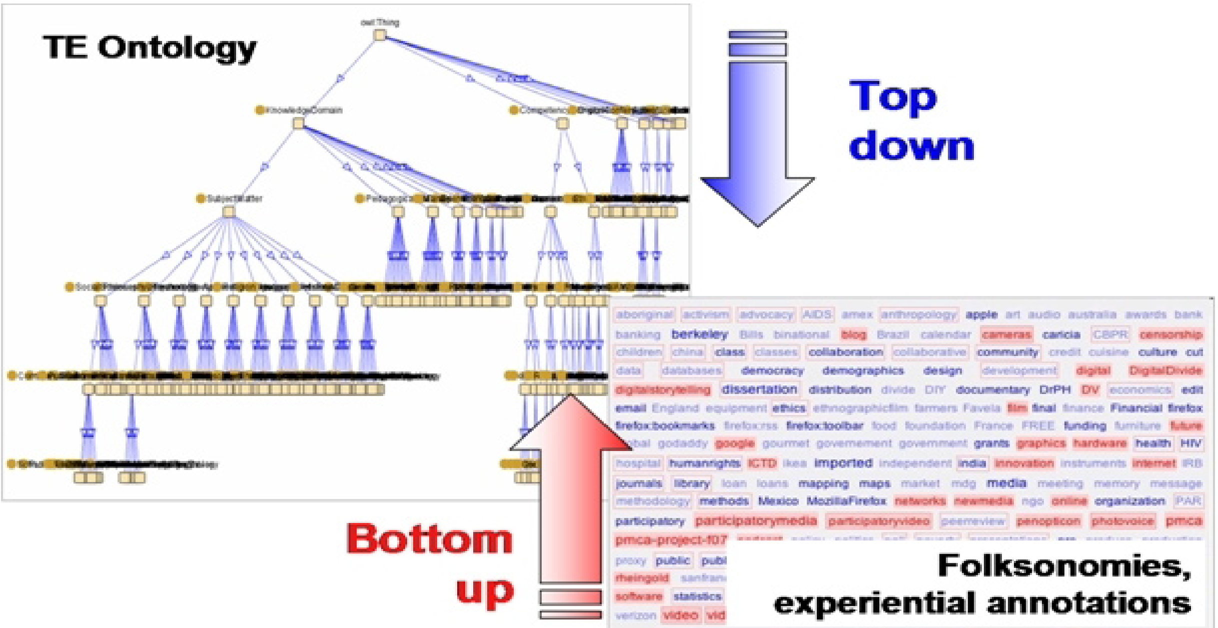

Figure 2: Integrated approach.

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Personal Transparency and Self-analytic Tools for Online Habits

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Abstract

TrackMe is a browser-based tool designed to allow users to analyse their online behaviour. It provides self-analytic facilities whereby learners can examine habits and see the impact of online engagement. TrackMe presents social mechanisms relating technological agency to social structure. However, encouraging learners and teachers to use it themselves has been challenging. Changing technological habit, we argue, is deeply challenging for learners and teachers, and that the sort of self-analytics that TrackMe provides may be unwelcome. Despite this, interesting discussions have emerged through confronting TrackMe, and we conclude that it may be the discussions that count in transforming habit.

Introduction

The SPLICE project has sought to understand the challenges of Lifelong Learning through the perspective of the personal technological habits of lifelong learners rather than the technological infrastructures of educational institutions. The project has investigated the assertion that it might be more effective for learners if institutions adapted curricula to instill effective online habits, and to investigate whether personal technological habit outlasts a learner's engagement with any single institution. Cast in this light, the challenge of lifelong learning is that to equip learners with the capacity to continually engage with learning opportunities entails significant personal transformation in the habits of both learners and teachers. The project has sought to understand the mechanisms of personal transformation with the aim of being able to harness those mechanisms more effectively to the benefit of learners and the viability of the education system as a whole.

With this in mind, we developed TrackMe, which was conceived as a tool to encourage learners (or teachers) to consciously address the issue of their technological habits. TrackMe encourages users to identify at any point "what are you doing?" as a way of categorizing the online actions that are taken. In its design, it was envisaged that being able to share things that are being done with others, and to share the actions that emerged from it, would provide a useful mechanism for reflection and vicarious learning. As a result, TrackMe includes both facilities for sharing of practice, together with sophisticated facilities for self-analysis. This paper describes the tool, and the rationale behind it. However, it also describes the difficulties in getting learners to engage with it. Having developed the tool, some interesting outcomes have emerged through trying to engage learners and teachers with tracking their personal technological habits, whilst at the same time articulating the broader context for why habit is so important. In a nutshell, the making of the tool has helped articulate and make real the issues of personal habit, whilst at the same time, the challenge of getting people to engage with TrackMe has helped reveal the extent of the deeply personal nature of technological engagement, and the major challenges learners and teachers have in revealing personal habits and transforming them.

The issue of Habit

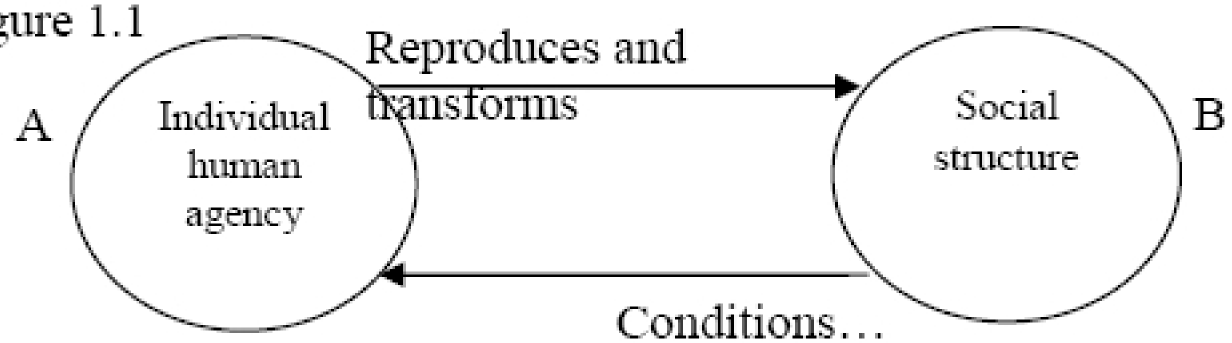
In work on the Personal Learning Environment (PLE) it has been identified that although technological development of the PLE could bring a wide range of online services together to create synergies, the synergizing process could not be 'provided' to the learner in a 'one size fits all' PLE (Johnson and Liber, 2008). Instead, the PLE meant that learners and teachers had to take greater personal ownership of technology, creating their own technological synergies to ensure that they coordinated their work and learning effectively. Inevitably, this strongly depends on the particular disposition individuals have towards technology, and that in a random sample of learners (or teachers) there is a wide range of different dispositions towards technology, which tend to manifest in the 'long tail' of disengagement with technologies (Johnson, 2008). However, the patterns of technological adoption as shown my Rogers (1962) or Moore (1991) indicate that individual technological habits may be transformed from a position of disengagement to engagement. The SPLICE project as a whole has been focused on identifying the mechanisms whereby this might take place, and key to this has been to understand the nature of 'habit'.

In recent years, much work has been done on habit and its relationship to personal reflexivity, personhood and social mobility. In part this is recognition of the fact that much of what enables a person to 'get on in the world' (Archer, 2007) is embodied in skills, practices and ways of thinking and talking, rather than objectively quantifiable in terms of the amount of knowledge gained (through exams, for example). Much of what brings individuals social advancement is 'tacit knowledge' (Polanyi, 1964) or what Merleau-Ponty calls 'embodied cognition' (1962). Bourdieu (1990), for example, argued that the embodied practices of individuals (or 'habitus' as he called it) was the personal means by which a person carried tacit knowledge and social status with them. This in turn allowed them to partake in larger-scale social structures through gaining 'social capital' (gaining membership of networks of influence and esteem), or 'cultural capital' (forms of knowledge which give social advantage). In short, attention on 'habit' throws into the spotlight the key distinction between: 1. the actions of an individual in society; and 2. the social structures that comprise the society within which the individual operates.

Bearing in mind this distinction between structure and agency, Archer (a student of Bourdieu) has argued that whilst social structures (within which might also be included technologies) condition the behaviour of individuals, greater attention should be placed on the role of personal reflexivity for transforming habit and disposition (Archer, 2008). It is with this focus on personal reflexivity for the development of technological habits that we developed TrackMe.

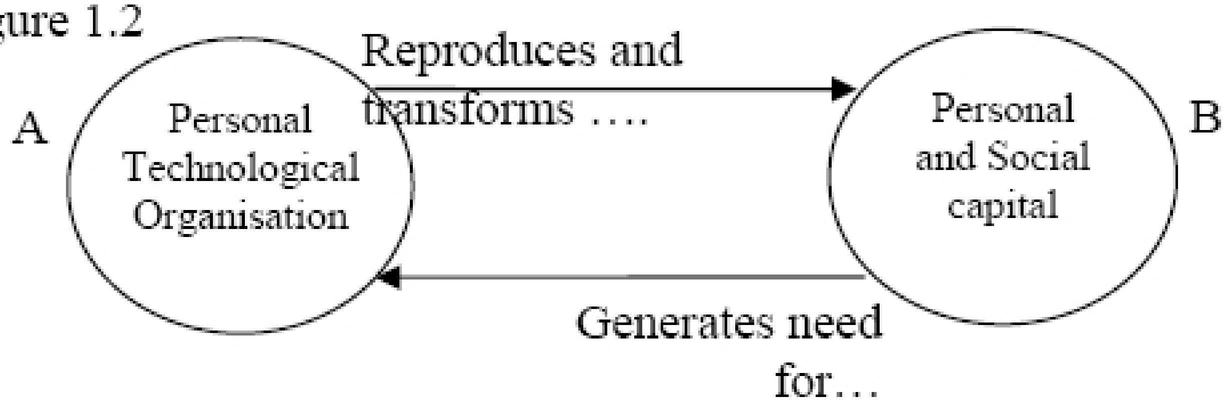
In focusing specifically on 'technological' habit, TrackMe recasts the relationship between structure and agency described by Archer (1995) and Bhaskar (1977) in a technological form. This relationship, illustrated in figure 1.1 suggests that human agency reproduces and transforms social structure (Bhaskar calls this the 'Transformational Model of Social Activity', whilst Archer calls this 'Morphogenesis'), whilst social structure conditions human agency.

Figure 1.1



In its technological form (Figure 1.2) we suggest that human agency becomes individual technological agency (Personal technological organization) which reproduces and transforms online social structures, creating social capital for the individual. As with the relationship between structure and agency, this is a circular relation, with the emergence of online social capital generating the need for more effective personal technological organization.

Figure 1.2



To summarise this theoretical outlook, it is argued that habits play a major role in the success of individuals in 'getting on in the world', and the formation and transformation of effective habits is clearly linked to learning. It is the assertion of the SPLICE project that many of these habits now revolve around computer technology. Given this priority, we might worry that in the present fast-changing technological environment teachers increasingly struggle to equip learners with the habits they require to make their way in the world – partly through a failure to recognize the importance of technological habits in themselves.

Introducing TrackMe

It is into this background that TrackMe was conceived as part of the SPLICE project. TrackMe was initially designed as a tool for making unconscious technological practices more conscious through providing a range of analytical tools. This, it was argued, might enable teachers to encourage learners to develop more effective habits, and to understand the nature of the relationship between individual technological practices and a fast changing world. It might also allow teachers to place more emphasis on acquiring the skills for technological engagement as a way of empowering learners to discover the content of their learning on the web (in forums, etc), rather than delivering that content themselves. This in turn might lead to greater personalization in the curriculum through a technologically-facilitated Inquiry-based learning (Millwood and Terrell, 2005) . TrackMe approaches these broader aims through a number of facilities, including the categorization and management of web-history, the sharing of practices through social networks, and the visualization of increasing online identity.

Practices with social software entail increases in personal transparency, and TrackMe aims to extend personal transparency in exposing patterns of individual online habit. In so doing, it opens up practices and allows for learners to compare these with those of others. By doing this, learners are able to identify strengths and weaknesses in technological habits, to improve their ability to foresee change and adapt accordingly. Transparency in TrackMe is obtained by using technological methods such as micro blogging (via Twitter), social bookmark (via Delicious) and a comparison facility that allows users to compare their user profiles with other users of TrackMe.

Twitter integration allows the user to create micro blogs about the subjects and resources they engaging with and also allows them to easily see the similar engagements that other learners are having. Figure 2.1 demonstrates a user searching for a resource they have used and found effective; the results show micro blogs from a global audience of learners and the ways in which they have used this particular resource themselves; this encourages users to find new and similar resources but more importantly promotes discussion between learners. The finding of new resources is also encouraged by social bookmarking integration which allows learners to save, tag and share resources.

Figure 2.1: Searching micro blogs in Twitter for a resource.

By introducing Twitter and Delicious it is hoped learners will build confidence in using such tools which are a critical piece of effective technological learning habit.

To reflect and collaborate. learners need the ability to articulate the habits they have; TrackMe encourages the growth of this ability through a feature set that allows analysis of user profiles and a comparison with that of others.

Figure 2.2 shows a timeline of resources used by a learner created by TrackMe's analytical functions; from these analytics users are able to see the which tasks they spend the most time on and the resources that help them to accomplish these tasks. Learners can then relay this information to other learners or a tutor; learners can also use this information for self reflection.

Figure 2.2: Timeline of learner's resources for a task.

Analytics are not only provided on a personal level but also between users; TrackMe's comparison feature set allows users to see how their resources compare with other users and offers learners a 'Random Resource' to help users discover new resources.

Having used TrackMe learners should be able to identify the things they do with technology that have a positive effect on their learning process.

Further self reflection is provided by integration with the Touchgraph Google browser which offers a visual representation of a learners engagement and activity on the web for easy analysis. Figure 2.3 shows a TouchGraph map of a learner's different online activities and connections that can be made between these. One advantage of this method of self reflection is in the learner being able to see and articulate where their learning habits have benefited from transparency and openness by showing which of the learners online activities interact with each other. Figure 2.3 demonstrates this by showing how a post at Blogger has acted as a catalyst between two resources resulting in a explosion of learner interaction.

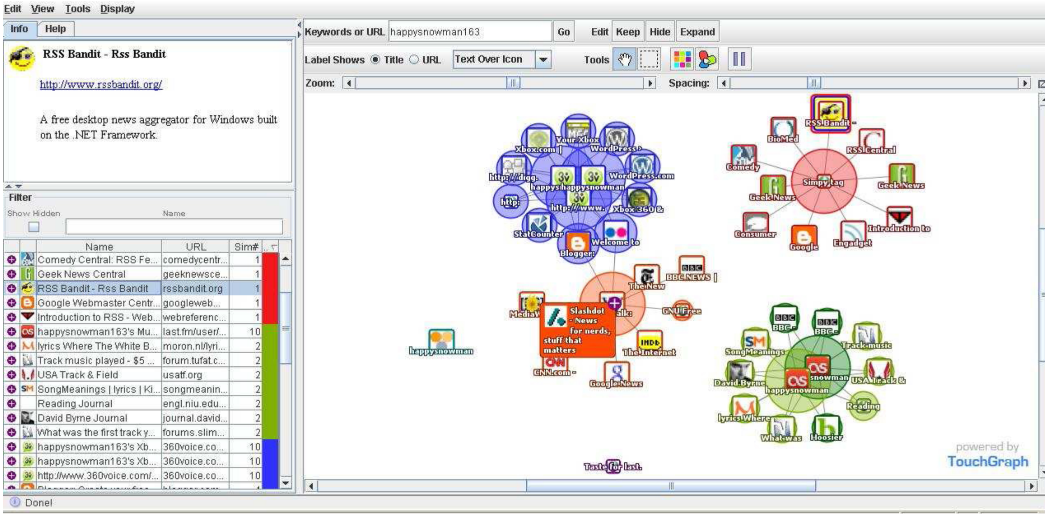


Figure 2.3: Touchgraph map of resources.

Analysis and Conversations

On exploring the analytical data from TrackMe, a number of questions can be asked. These include:

- How effectively do your technological actions meet the goals you establish?
- How much repeated effort do you use in accessing multiple webpages?
- To what extent do you find yourself getting 'distracted' by online engagement?
- Can you remember all your passwords?
- How much time do you spend 'refinding' things that you have previously found?
- Can you detect any change in your habits?
- Is your online profile rising as you explore the internet?

Beyond these particular questions lie more practical recommendations as to how learners might improve their habits. In answer to each of the questions above, were some practical suggestions:

- Using RSS to aggregate frequently visited web pages
- Developing more effective search habits and saving them
- Using Identity management techniques to manage passwords
- Using Social Bookmarking services
- Making more effective use of public social action (Youtube, etc)

These questions can also be applied to learners who compare their habits with those of other learners.

TrackMe in the Classroom

TrackMe was used with a mixed group of learners from Multimedia and Visual Art courses at a Further Education institution in Wales. Its introduction to the group was conducted within the context of a 'Common' module which had previously led learners through a series of activities relating to the management of personal complexity, and the importance of engagement with technology (and particularly social software). In the broader context of the SPLICE project, many learners were already engaged in the online social network for the SPLICE project (http://splicegroup.ning.com). Learner participation within this social network revealed a typical pattern of the 'long tail' of disengagement similar to that indicated in previous work with social software (Johnson, 2008).

As with the introduction of any new software, TrackMe was first of all demonstrated to the group. In this demonstration, learners were introduced to something which gave a direct representation of effects of improving technological habit on the rise of personal online identity could be clearly demonstrated. This demonstration itself provoked discussions between learners and the teacher. However, not all learners were happy at being coerced into engagement with TrackMe, and some felt an 'invasion of privacy' – despite being reassured of the control they had over their data. Reassurances and some compromises in terms of the activity they were asked to engage in all had to be in place before they were comfortable to engage with the exercise. These were the principle barriers to signing-up for social software services (e.g. Twitter) and downloading the TrackMe tool. Indeed, where individual learners appeared to be having 'purely' technological problems, it was often the case that addressing deeper misgivings about what they were being asked to do improved their ability to perform the technological tasks.

Once technological/personal problems had been overcome, the facility of TrackMe which was of most interest was the integration of the TouchGraph (www.touchgraph.com) Google browser for mapping personal presence on the web. Learners were keen to situate themselves, and to compare their positions to others. When it was demonstrated that increased engagement with social software services brought about through the investigation of personal technological habit would impact on that social position, increased interest and engagement with the TrackMe tool was noticed.

This experience proved a foundation for talking about the bigger issues relating to the importance of technology, technological habit and personal empowerment. Again, this provoked deep discussion amongst learners.

Personal Technological Habit and the SPLICE project

Despite the mixed success of TrackMe, the SPLICE project has produced a series of indicators of the efficacy of habits in lifelong learning and the mechanisms which link educational interventions like TrackMe to the emergence of those habits. To elucidate these mechanisms, the project has employed methodological techniques for the evaluation of the different interventions used in SPLICE, including TrackMe. These techniques have derived from the 'Realistic Evaluation' approach presented by Pawson and Tilley (2004), which in turn derives from the Critical Realism of Bhaskar and Archer.

The objective of the Realistic Evaluation method is that different mechanisms for observed project outcomes may be compared and discussed for their respective explanatory and predictive power. With a large number of stakeholders in the project, ranging from practitioners in the Creative Industries, to teachers and learners, together with a varied range of observed outcomes – from positive experiences to negative ones – this presents organizational challenges in creating a democratic forum for the exchange of ideas of possible mechanisms. The evaluation of SPLICE has approached this through a collaborative mind-mapping technique using a combination of a modified version of the Freemind (**http://freemind.sourceforge.net**) open-source mind-mapping tool together with Twitter for data input. This technique was used within a one-day group evaluation session with 15 project stakeholders. Drawing on techniques already established for large-scale collaborative discussion – notably Beer's concepts of 'problem jostle' and 'counter-conference' (Beer, 1994) – the evaluation of SPLICE proceeded to concentrate on two main areas of the project: 1. individual transformation of habit; and 2. transformation of institutional structures. During the evaluation day, the morning was given over to discussion about personal change, and the afternoon for discussion of institutional transformation. Here we report on the former strand of questioning, as it relates to the personal challenges that TrackMe attempts to address.

The mind-mapping approach was used to hone-in on possible mechanisms through an iterative 3-stage process:

1. brain-storming and capturing possible answers to a question
2. reflecting on results and voting for most effective answers
3. drilling into chosen issues and repeating the process

The process was coordinated by a facilitator whose job it was to ensure fair representation of all stakeholder views. Stakeholders submitted ideas and voted through Twitter.

The process began by asking how people have changed over the course of the project. Despite some worries about "technophobes getting left behind", or an "over-dependence on technology", the majority of stakeholders present at the evaluation described positive experiences. The top-ranked indicator of personal change was the realization that 'I became more relaxed about what I put online'. This was pursued by asking about the causes of this 'increased relaxation'.

Answers to this revolved around the emerging realisation that there was a large community of practice engaged in online social activity, with an increasing awareness that participation in online activity was an indicator of the social capital of an individual ("starting to judge other people by their online exposure"). The top-rated response in this iteration was that increased relaxation in putting things online was due simply to "realizing the value of online engagement".

This raised the issue of "what is the value and when do you see it?", since identifying 'value' appeared to be the principle cause for engaging with the technology. The iteration under this question produced responses suggesting that value lay in getting feedback and building relationships online. This may be seen to confirm the theoretical perspective that the emergence of social connectivity online drives the increase in online habit. In this iteration, however, the top-rated response suggested that for some, real 'value' lay in what was still not put online. This raised the question of the distinction between that which is deeply personal and that which people are happy for others to see, and following this, the question of whether the boundary between 'public' and 'private' life is changing in the light of technology. In turn, the differences between those who are disposed positively towards technology and those who aren't became the focus of the next iteration.

Here, understanding the 'relevance' (as opposed to the 'value') of technology was considered important, together with an ability to change habits in the light of new developments. These issues of personal difference distilled to the differences between individuals who explored future scenarios in the light of new technological developments, and those who detected threats in technology to personal life. Finally, this led to a focus on the mechanisms whereby individuals organize themselves, with differentiation between those for whom priority was given to 'future gazing' and experimentation, and those who sought to remain in touch with embodied human experience and felt the need to 'protect' it from technology. This led to a discussion around the fact that the discussion itself was part of what technology does: that whether technology does or doesn't work; whether users like or dislike it, there is something to talk about.

Conclusion

Given the results of the evaluation day for SPLICE, the experiences with TrackMe can be seen on a number of levels. The difficulty with getting users to engage with TrackMe may be seen as indicative of the fact that there are some things which learners (and teachers) are not happy exposing – even despite the fact that TrackMe data is in the control of the user. The habits of individuals are deeply personal, and (drawing on the evaluation) possibly more 'valuable' than engagement with social networks. Having said this, many who didn't engage in TrackMe nevertheless changed their personal habits over the course of the project and reported positive experiences as a result.

Nevertheless, through the presence and use of TrackMe, something of the value of social networks can be articulated to learners and 'made real' which would otherwise be much more difficult and abstract. Moreover the mechanisms, which SPLICE exemplifies, of the relationship between 'structure' and 'agency' were borne out in the evaluation discussions. In short, the technology presented something to talk about. The issues raised by TrackMe are still (at this point in time) being talked about by learners in the group, and gradually new practices emerge with those discussions. This gradual emergence of habit clearly requires a more longitudinal study, but it is not unreasonable to attribute some causal significance to the sorts of conversations that use of tools like TrackMe initiates. Indeed, whether the tool provokes enthusiasm or skepticism, conversations occur which wouldn't otherwise have occurred, and as the overall project evaluation seems to suggest, those conversations themselves appear to have significant causal efficacy in the transformation of online habit.

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A Model for European e-Competence Framework Development in a University Environment

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Abstract

The paper describes a model of implementation of the European e-Competence Framework in Sofia University by using the methodology and tools developed in the frames of the EC Sixth Framework European Integrated Project Ten-Competence. The work is a follow up activity of an internal university project for implementation a curricula in computing based on the ACM/IEEE recommendations.

Keywords: *life-long learning, competence development, ICT practitioner*

1. Introduction

As a result of an internal university project for redesigning the computing curricula according to the ACM/IEEE CC2005 series recommendations[1] and several European ICT curricula recommendations, Sofia University (SU) has developed bachelor programs in Computer Science, Software Engineering and Information Systems [12]. In addition SU offered a large number of ICT master degree programs and most of them included **compulsory internship** student placement. The programs are oriented mostly **towards needs of global ICT industry**. The Centre of Information Society Technologies at SU took the initiative of opening the university towards life-long learning provision [8]. Recently the Centre was identified as an example of good practice in multistakeholder partnerships for e-skills in Europe [7]. The academic programs were enhanced with courses provided by some big vendors. A set of courses were opened to external clients, coming from industry, government and other organizations. The **cooperation with the local ICT industry** is considered as a strategic goal of the university in order to better adapt the computing curricula towards the needs of this industry, and to open doors for a professional carrier for every graduate. Several bi-lateral programs for carrying out student internship programs with some local ICT companies were launched. Every student has two tutors – one from the university, and the other - from the company, and each internship ends with evaluation by a company tutor. Usually after the internship students receive offers for full time position at the same company. In parallel, some organizational changes were driven towards implementing a new model of university [9,10,11]. The model we are heading is **eUniversity**: *a research and entrepreneurial university which integrates ICT in all university activities, including the ones related to the outside knowledge intensive organizations* [9].

2. Towards e-Competence Framework Development

The fast growing e-Skills gap is a major concern of the EC and other European stakeholders[4,7]. The European e-Skills Forum has clasified "e-skills" in three main categories: **ICT practitioner skills**, **ICT user skills** and **e-Business skills**. In May 2008 were adopted *the Recommendations of the European Parliament and the Council on the Establishment of the European Qualifications Framework (EQF) for lifelong learning*[13].The recommendations aim to contribute to modernising education and training systems, the interrelationship of education, training and employment and building bridges between formal, non-formal and informal learning, leading also to the validation of learning outcomes acquired through experience. There were defined **eight levels** of the EQF in terms of knowledge, skills and competence. The main objective is **to create a common reference framework** which would serve as a translation device between different qualifications systems and their levels, whether for general and higher education or for vocational education and training. This will improve the transparency, comparability and portability of citizens' qualifications issued in accordance with the practice in the different Member States. Each level of qualification should be attainable by way of a variety of educational and career paths.

In September 2008 were published the European e-Competence Framework - e-CF (version 1.0) and the user guidelines for its application [2,3]. The initiative of development of e-CF has been launched as a **multistakeholder partnership** by a large number of European ICT and human resource experts. The e-CF is focused only on the ICT practitioner Skills and would make possible **creation of a long-term human resources and competence development strategies** for the European ICT community. The e-CF is structured from **four dimensions** which reflect different levels of business and human resource planning requirements in addition to job/work proficiency guidelines (see fig.1).

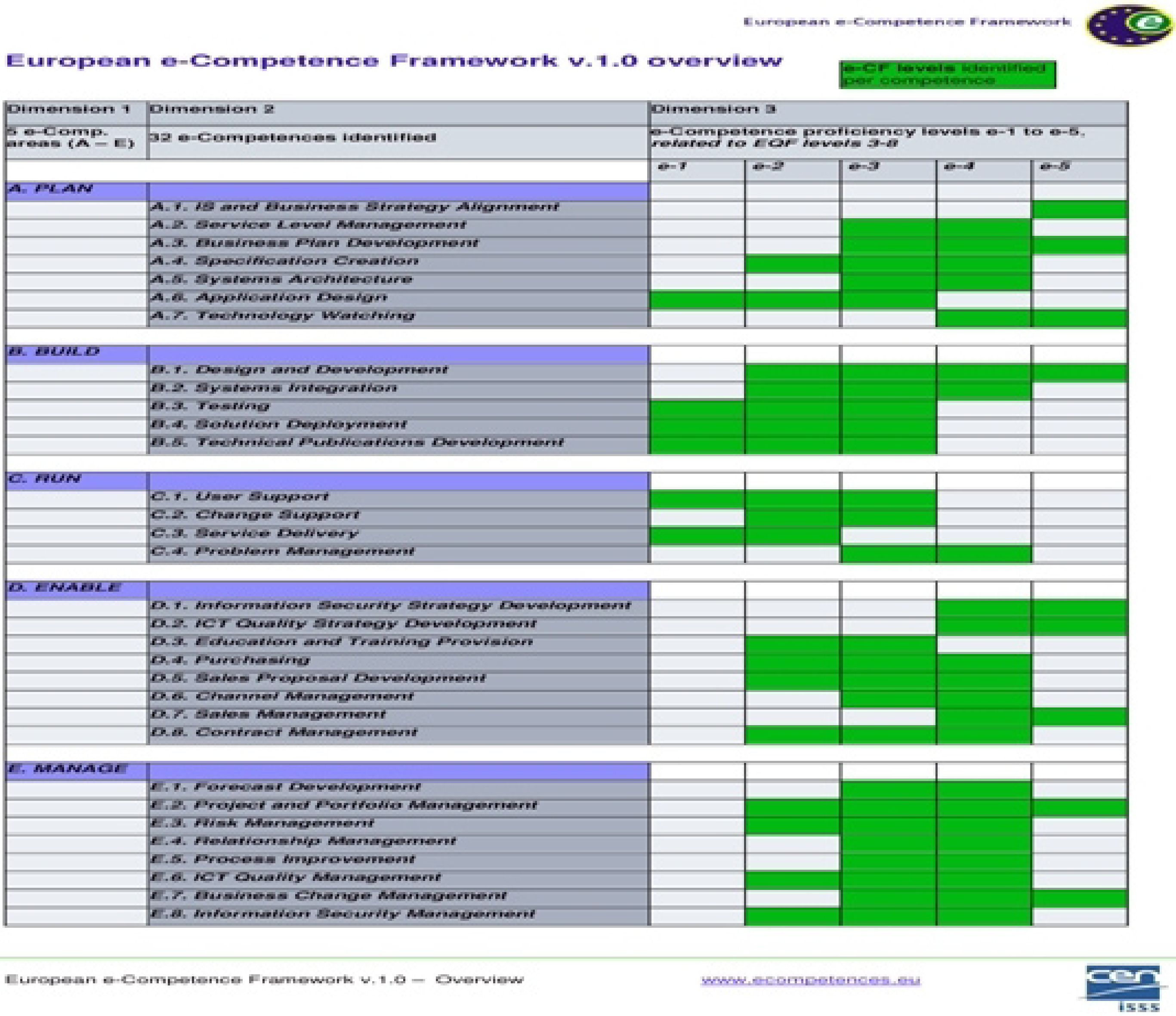

Figure 1: European e-Competence Framework v. 1.0 [2].

3. The TENCompetence Project

SU actively participates in the EC Sixth Framework European Integrated Project TenCompetence [16] which develops methodologies and tools to support "*individuals, groups and organizations in Europe in lifelong competence development by establishing the most appropriate technical and organizational infrastructure, using open-source, standards-based, sustainable and innovative technology*"[6]. A pilot for training of university professors in using the the Personal Competence Manager (PCM) - a tool developed in the frames of the project[5], was run [15]. A large scale in-service teacher training pilot based on the TENcompetence framework was designed and run as well. In addition - two new pilots are under preparation - a pilot on expansion of the Special Education Bulgaria (SEB) internet community [14] and a pilot for consultation and training of a middle size company in the field of electronics how to describe training in terms of competences, subcompetences, how to move from a topic-based training to a competence-based training.

The above mentioned pilots target developing ebusiness and ICT user skills, while the e-CF is mostly oriented towards development of ICT practitioner Skills. Our next challenge is to pilot implementation of the e-CF by using the TENCompetence framework.

4. Design issues of implementation of the e-CF

At the first stage some alignment of the definition of **competence** is required. In the EQF, a competence is defined as "*the proven ability to use knowledge, skills and personal, social and/or methodological abilities in work or study situations and in professional and personal development*"[13]. In the terms of the e-CF, a competence is "*a demonstrated ability to apply knowledge, skills and attitudes for achieving observable results*"[3]. The TENCompetence consortium interprets competence "*as all the factors for an actor to perform in an ecological niche*" [6]. Performance includes the specific context that is necessary for the interpretation of competence and competences include competencies and knowledge that are necessary to put the competence into performance. All three definitions are semantically close and the difference in their meanings would not influence the further work.

The European e-CF provides a framework for a multistakeholder partnership between universities and companies since it represents the competence needs of the ICT industry which could reflect on designing and refining the academic programs (see fig.2).

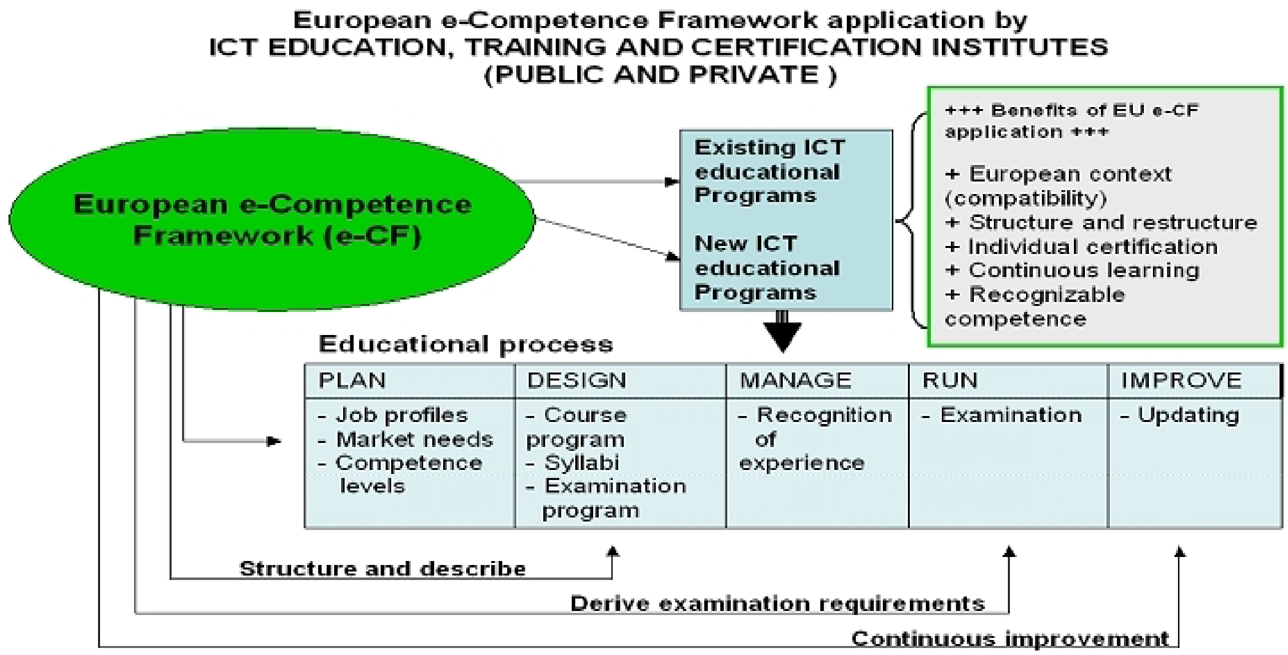

Figure 2: e-CF application by ICT education, training and certification institutes [3].

A process of matching the developed computing curricula at SU towards the European e-CF is initiated and it will reflect its further alignment and enhancement at all four e-CF dimensions for the bachelor, master and doctoral level of education. For instance, the implemented bachelor curricula at Sofia University correspond mostly to the e-Competence area "build" (see fig. 3).

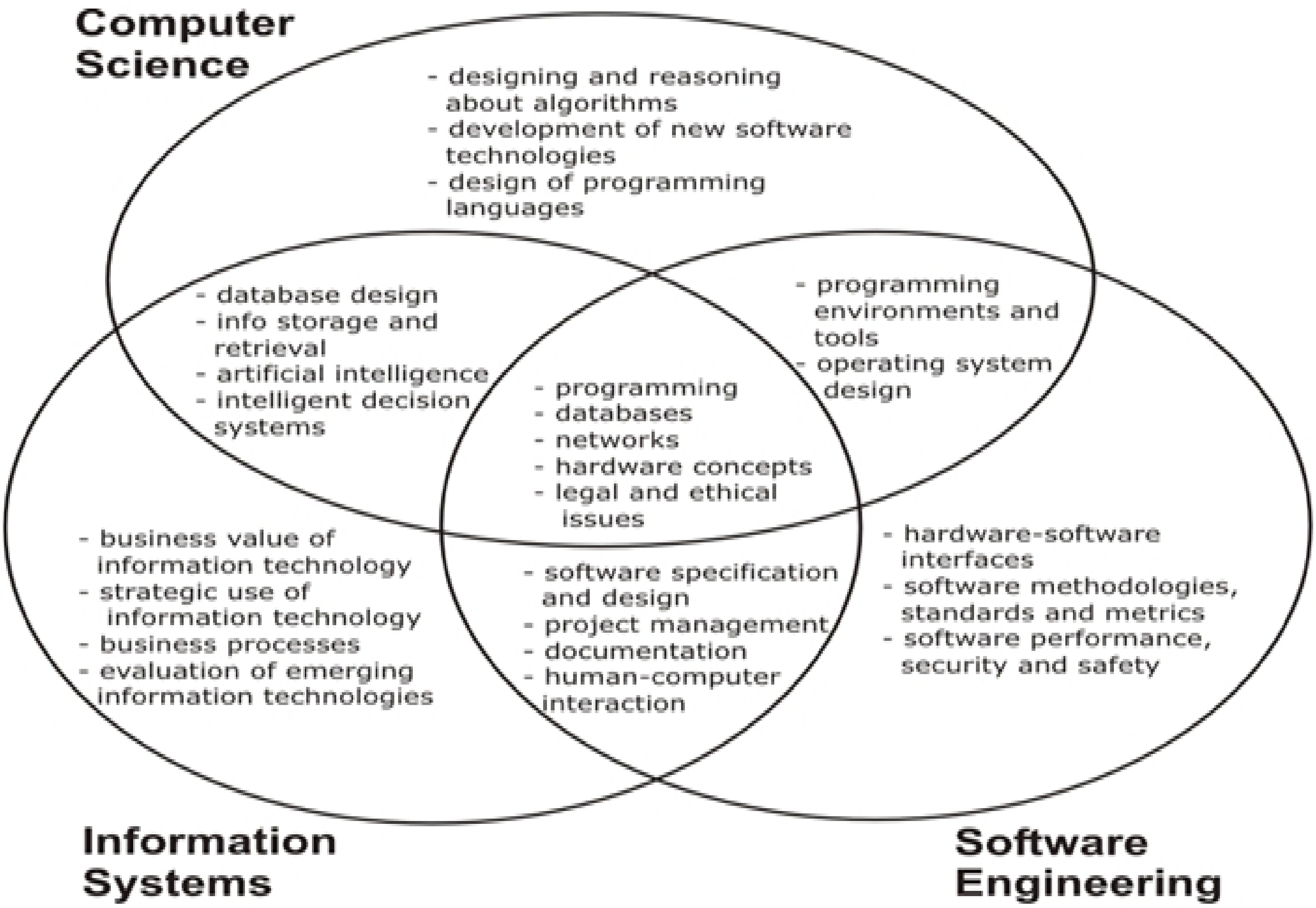

Figure 3: Intersection of the Computing Curricula in CS, SE and IS.

It was identified that only few of the ICT master programs at the university target the other 4 areas, e.g. the master programs in "*e-Business and e-Governance*" and in "*Technology Entrepreneurship and Innovation in IT*". The further efforts will be directed to embedding in the curriculum more skills and knowledge from the framework and open more close cooperation with the other ICT stakeholders for better covering the requirements of the European e-CF. Since almost all master students work at ICT companies, they are obliged to develop their ICT competence in a real work environment. The European e-CF provides an opportunity to **closer bridge academic education with the student internship program** in ICT companies for further ecompetence development in a systematic way. An opportunity is to use the e-CF for supporting students to develop their own ICT carrier and become real ICT practitioners in the companies they work. For instance – they can use the framework for defining their own learning path, self assessment and making visible their personal competence profile. On the other side, the companies that are included in the internship program, could be supported to use the European e-CF for: preparing job descriptions by combining elements from different areas and recruiting people who better match their needs; analyzing the skills gaps and developing training plans for their employees; further supporting development of skills in order to meet the changing demand of skills, etc.

5. Conclusions

For the purpose of the further work the PCM system and already accumulated experience in its application will be used. PCM is not designed around concepts like lecture, course, training program, but rather on concepts like learning network, competence profile, and competence development program[5]. PCM gathers competence related information drawn from sources at multiple levels, and presents this information in a context, structure and format, which are determined by the user. The PCM users can initiate or join a virtual professional community, support development of its competence profile, design competence development plans for each competence profile. Each plan may contain several learning paths, comprised by different learning activities and supported by specific knowledge resources. The users can choose their own competence development plans, follow them and thus built the desired competences. They can rate any existing plan, activity or resource in relation to achieving specific competence profile. The learners can share their plans, ratings, resources and ideas using the embedded communication tools. There exist a self-assessment instrument and a *best way* map that helps learners to find the most efficient for them learning path through any competence development plan.

Acknowledgements

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The Future of Learning Designs: Making Them Useful and Useable for Teachers and Learners

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Abstract

The notion of 'learning design' as a means to document and disseminate formalised descriptions of learning and teaching experiences has gained signification attention in recent years, and has given rise to a wide variety of different tools and strategies which draw on the idea. A distinct strand of this work has focused on the support needs of teachers, who are 'non-expert' designers in the sense that they are not formally trained as instructional designers, but nevertheless undertake design activities as part of their routine teaching practices. Learning designs that encapsulate and communicate good practice have the potential to provide teachers with an opportunity to extend their repertoire of designs, in so doing advance their knowledge and skills in new forms of pedagogy. By analogy we might also consider what learning designs might offer learners as a mechanism to develop new skills for lifelong learning. This paper reflects on the current state of learning design tools and strategies for teachers, and considers what these ideas might offer for learners.

Keywords: *learning design, teacher, learner, lifelong learning*

1. Learning designs for teachers

Support for improving educational design has emerged as a critical issue for many universities as they strive to improve student learning by effectively integrating new pedagogies and technologies. High quality educational designs are essential to enhancing learning outcomes, particularly in an era of increasing diversity in student populations and in which institutions also need to equip students with lifelong learning skills essential for the contemporary work environment and participation in society more generally. At the same time many institutions are increasingly integrating online learning activities and tools to better support and engage their students. These factors place particular pressure on university teachers to design and create effective learning experiences for their students. It is this context in which much of the work on 'learning design' has been situated to date.

Recognition of the importance of educational design support has long been evident in the significant investments that the institutions make in learning and teaching support services, but also in the support for initiatives focussed on sharing and building on good practice. This over-arching concern has led to the emergence of a relatively new area of scholarly and research activity, 'learning design', which has focused on ways in which university teachers can document, model, implement, share and adapt learning design ideas [1, 2, 3]. A variety of different strategies and tools has emerged to address this common goal, and which complement more technically-oriented activities [1].

One strategy to encourage sharing has been to create Web-based collections that allow teachers to publish, search for and comment on learning and teaching ideas. Three examples of these types of collections which encourage participants to document and share descriptions of their ideas and designs are the *Technology-Supported Learning Database* (available at **http://aragorn.scca.ecu.edu.au/tsldb**), the *Phoebe Pedagogic Planner* [4] (see **http://phoebe-app.conted.ox.ac.uk**) and *Cloudworks* (**http://cloudworks.open.ac.uk**).

An alternative is to use a systematic formalism for sharing descriptions, for example through pedagogical patterns [5] (see for example the PLaNet project,

http://patternlanguagenetwork.org/about) or a learning design sequence [6] (eg. the Australian learning designs project, **http://www.learningdesigns.uow.edu.au**).

At the same time, work is advancing on tools to support aspects the educational design process, examples of which include tools that:

- allow teachers to easily construct and deliver sequences of learning activities (eg., the Learning Activity Management System, **http://www.lamsinternational.com**)
- support pre-course analysis and planning by lecturers (eg. The London Pedagogy Planner, **http://www.wle.org.uk/d4l**; [7])
- allow for the customisation of learning resources (eg. Generative Learning Object Maker, **http://www.glomaker.org**; [8])
- create a visual representation of their designs (eg. CompendiumLD, **http://kn.open.ac.uk/public/workspace.cfm?wpid=8690**; [9])
- provide support for adapting existing design ideas [10, 11]

While these initiatives have similar general aspirations to foster sharing of learning designs, each of these approaches and tools has conceptualised the problem in different ways, which has led to different outcomes. As a result, there are variations in the types of support each can provide, for example, by targeting different aspects of the design process or promoting different types of design practices. It is therefore likely that different strategies and tools may be more or less effective depending, for example, on the nature of the design activity or the support needs of the teacher. For example, some strategies and tools might be more helpful in assisting with high level conceptualisation of a new subject design or significant redesign, while others may assist more with fine grained planning of specific learning activities. It may also be the case that some strategies and tools are most useful to beginning teachers, while others help to advance the practice of those who are more experienced.

These differences, however, are yet to be systematically explored in a way that could inform the field more generally about supporting design. This research is needed to investigate how these types of tools and strategies integrate with teachers' existing design practices, an area which is also under-researched [12]. This work is critical to understanding how we can make the most of technical advances to support real practice.

2. Learning designs for learners

Given that a significant focus of learning design to date has been on developing teachers' design skills, it is worth considering what form learning design might most usefully take for learners. In fact, it might reasonably be observed that such a focus is overdue. Rethinking learning design in a way that makes it genuinely more 'learner-centred' is not, however, a trivial exercise. It is not simply a matter of transferring the focus from teacher to learner, nor it is necessarily a matter of removing the teacher altogether. Instead, we must consider in what ways a learning design might be useful to a learner. At its most simple we could think of learning design for learners as being a means of communicating the teacher's design to student. We must, of course, recognise that a teacher's learning design represents his or her aspirations for the unit of study rather than a rigid plan. That is, a learning design that a teacher develops prior to the commencement of a session documents a teaching plan which may, or may not, be enacted precisely as intended. In this sense a design intends to create the circumstances in which particular learning activities can take place, but does not necessary prescribe these fully ahead of time.

For example, a teacher might schedule an asynchronous discussion to occur in a particular week of a session and post a question shortly before the discussion to provide a stimulus for conversation. However, after the discussion commences the actions of the students and teacher are no longer predictable in way that can be designed for. In this way the design for learning and teaching gives way to the enactment of learning and teaching. Despite this necessary difference between design and enactment, it may nevertheless be useful for the learners to have access to the teacher's design because it may help them to more easily comprehend the nature and structure of the unit they are studying.

For this application to be useful, the learning design should communicate the sequence of activities, the way those activities relate to the resources and supports provided in the unit, and provide some indication of the pedagogical rationale behind the design. A learning design like this, presented to learners, might therefore give learners insight into the reasons they are being asked to participate in a learning activity, why they are being asked to undertake it in a particular way and in a particular sequence with other activities, and what learning outcomes they might aim to achieve in the process.

Seen in this way a teacher's learning design communicated to learners might appear almost prescriptive, but this does not have to be the case. It is quite possible to envisage a learning design communicating a very open-ended activity in which learners have significant choices about, for example, the nature of a project they wish to pursue or a problem they wish to tackle. For example, we might consider a learning design in which the teacher decides she will offer her students a self-directed project, specifying perhaps the types of outcomes that should be achieved but leaving the topic, the method, the final output and the assessment criteria as negotiable and to be developed by the learner. Although some aspects of this learning experience have been 'designed' ahead of time, much of what occurs is determined during the learning session by the learners. Again, having access to the learning design may enable learners to comprehend the overall sequence and nature of the unit, and understand what they must develop themselves as part of the learning experience.

Another possible application of learning designs that are targeted towards learners are designs that support individual or group study activities that are undertaken independently of a teacher, that is activities outside of class but still within a formal education setting. These might provide a means to improve learners' study skills so that they can undertake individual and group learning activities more effectively.

There has been a long history of academic study skills development for learners, but much of the advice available to learners has been provided in the form of tips for effective note-taking in lectures, essay writing or time management, for instance. Learning designs that describe particular sequences of learning tasks which suggest ways in which those tips (and others) might be put into practice may offer a new approach to offering this type of support. Likewise, learning designs could describe sequences and combinations of activities that might support peer-managed group work.

In both cases the reason for offering learners a range of learning designs, some of which they may not have encountered previously, is to extend the repertoire of strategies that individuals and groups of learners have available to them. It is important to be clear that such learning designs would offer 'suggested' strategies which learners might then choose to attempt depending on their preferences. Additionally, it is important to acknowledge that there may be a range of different learning design sequences relevant to one particular learning goal.

Thus, the aim would be to build experience of different strategies rather than suggest that there is only effective strategy for any given learning problem. Access to a suite of learning designs would hope to enable learners to see new options explicitly rather than leaving them to reply on their current strategies, and perhaps hope that they will discover news ways of learning by chance or luck. Importantly, such a strategy could focus on supporting learners develop the range of skills important to developing autonomy and becoming lifelong learners.

3. Conclusion

Reusable or adaptable learning designs have the potential to be useful to both teachers and learners. In both cases learning designs may offer opportunities for individuals to extend their existing repertoire of strategies and advance their skills and practices. For teachers, learning designs have the potential to scaffold their use of new pedagogies and to encourage them to make learning and teaching activities more explicit to their students. For learners, learning designs may support individuals to develop new lifelong learning skills which they may not otherwise have the opportunity to experience. In both cases, however, there is significant research to be done on the circumstances under which learning designs might be most useful and the forms of tools and strategies that might make them most usable.

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Functional and Non-functional Requirements for Building Service-oriented Assessment Model

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Abstract

This paper presents the service-oriented architecture for tools that supports assessment activities in learning proc-ess and learning outcomes, suitable for lifelong compe-tence development. To address this more general objective the following goal was established: to develop a new integral assessment service-oriented architecture that includes modern assessment approaches along with the classical tests. What is described in the first part of the paper is the assessment process which was divided into the following stages: Assessment design, Item construction, Assessment construction, Assessment run and Response rating. Then some more general architecture of the assess-ment process conform to the SOA specification is pre-sented, functional and non-functional requirements are provided as a base for developing of that architecture.

Keywords: *SOA, assessment model, functional and non-functional requirements, assessment services*

Introduction

A Service Oriented Architecture (SOA) is a soft-ware model in which the concept of a 'service' is an abstraction of a function used by an applica-tion.

Thousands of enterprises worldwide have adopted the principles of Service Oriented Architecture. SOA provides an architectural approach that brings the flexibility and agility required by today's global business environment [1, 5].

SOA addresses the business demand for applications to be responsive to business needs and to adapt to dynamic business environments. In SOA, services may be defined as Web services to provide a standards-based approach to interoperability.

The paper focuses on the build aspect of the service-oriented architecture of the TEN-Competence Assessment Model. To achieve that goal, it is necessary to describe requirements drive downstream design and development to transform assessment processes into composite applications that automate and integrate the business. The solution is designed to ensure that they are flexible and can be adapted as needs change.

The solution complies with the following general non-functional requirements:

- TENCompetence framework - the solution uses data and programming languages that allow integration of platform with existing infrastructure of TENCompetence framework (java, xml).
- Architecture of Assessment Model - the system must provide extensible architecture in order to achieve high adaptation for current needs as well as to give opportunity to extend it for future needs [2].
- Services Based Architecture - the solution must provide service architecture for higher flexibility and easy improvements.
- Interface to be user friendly and to have appropriate coloring scheme, with no contrasting colors (except for the error and warning messages).
- Repository - the solution must support a repo-sitory with Unit of Assessment xml templates, and to give tools for easy access to them.
- Standards-based - wherever possible and practical, the tools and service should conform to IMS QTI standards and specifications.

Assessment model

The TENCompetence Assessment Model aims to cover the life-cycle of the assessment process. That model makes it possible to implement vari-ous assessment techniques which allow develop-ment and design of assessments that are specific for the competence development [3].

The model is built on several sub-models, each matching a different stage in the assessment process (fig. 1). According to the Assessment model, there are five main packages which de-scribe all the functionalities of the assessment process.

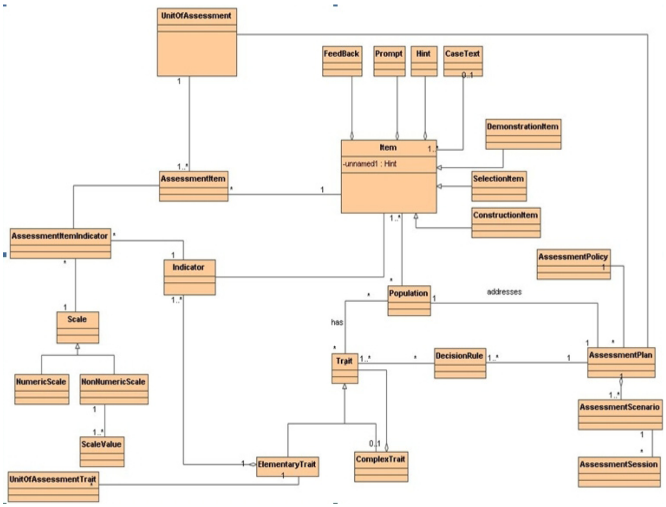

Figure 1: TENCompetence Assessment Model.

The Assessment Design stage defines Assessment Plan which is a complex object containing different factors and guidelines from the pedagogical model of the assessment. The Assessment Plan focuses on specific traits of the individual person(s) or group(s) which are assigned to it, by using the decision rule as well as specific assess-ment policy which has to be followed.

In the core of the second package (Item Construction) is the Item which can be of a different type: a construction, a selection and a demonstration. For the proper description of the functionality of the Item, the following components are used: Prompt, Case text, Hint and Feedback.

In the Assessment Construction package the output is the Unit of Assessment which consists of one or more Items according to the Assessment Plan. It defines the type and value of the Scale which specifies how the candidate's response has to be translated into a score.

The Assessment Run package is the process where the candidate undertakes an assessment and his/her answers are recorded in the ItemResponse for every single Item. There are two main objects: AssessmentTake and ItemResponse.

In the Response Processing package the main object is the Assessor. It is responsible for two major steps: to transform the candidate's response, represent as Item Response in the model, into a rubric score using the defined transformation rules and to calculate the Assessment Indicator Score for each candidate.

Research methodology

Our research approach is based on the following methodology (Figure 2):

- Overview of the problem(s) in the assessment area (stage 1),
- Design model, described in 'Assessment model' section (stage 2),
- Development of prototype software tools (stage 3),
- Tool evaluation and analysis (stage 4),
- Based on results – development of a service-oriented architecture (stage 5).

In the current paper more or less we concentrate our work on the last bullet – stage 5, which comes as a result from stages 1-4.

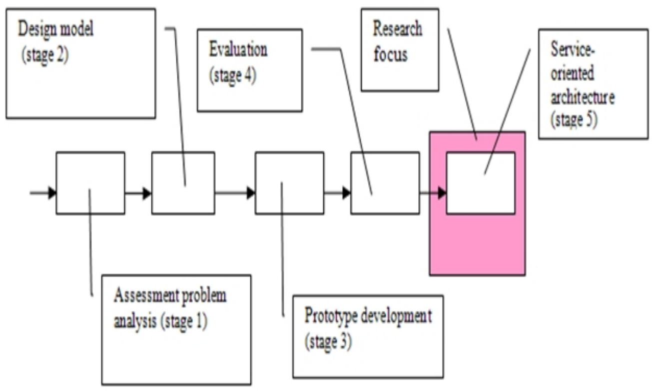

Figure 2: Methodology steps in assessment SOA development.

Thus the focus is on developing SOA for assessment.

Service-oriented architecture of the assessment model

When transforming the architecture to a SOA, an important step is the definition of the services.

Figure 3 shows the SOA of the Assessment Mod-el. The following overview provides a brief look at capabilities, how they fit into an SOA approach, and the technologies that support them.

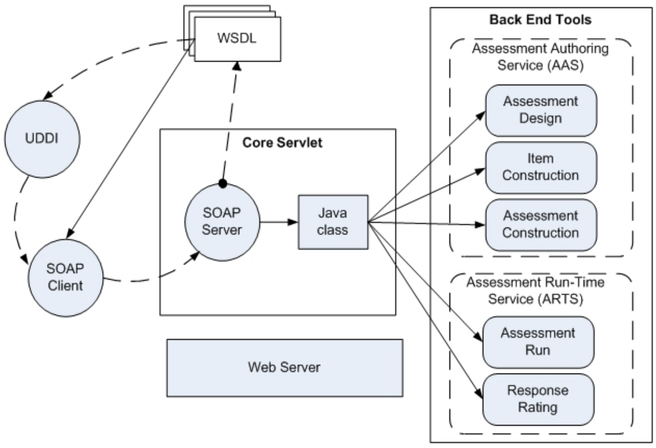

Figure 3: SOA of Assessment Model.

Assessment Design Service (ADS)

This service will be responsible for the creation and editing of an Assessment Plan. The main object is the Assessment Plan. It is defined in terms of units of assessment and their assessment types, as specified from the assessment scenario, determining their sequence and time dependencies. The Assessment policy prescribes which assessment types (methods) can be used and under what conditions. The Trait is an abstract object used to measure different personal characteristics. Identifying the most appropriate people to rate the performance of the individual is a key part of the process. Ideally, the recipient will have full involvement in identifying who they think is in the best position to comment on their performance. In the context of the Assessment Model, all participants in the process are called Population, and the assessed competence or performance level - Traits. It is also important to consider briefings with all participants on the objectives of the process and some basic tips for completing the questionnaire, called Assessment Policy, for example highlighting the importance of marking observed behavior.

Assessment Construction Service (ACS)

The central object in this stage is called Unit of Assessment. Each Unit of Assessment corresponds to particular Type of assessment and includes one or more Items. It defines the type and value of the Scale which specify how the candidate's response to be translated into a score. There are two types of scales: numeric and non-numeric scale. Unit of Assessment will be loaded and stored into the local file system; a special repository or specific database in XML format are easy to be accessed and re-used.

Item Construction Service (ICS)

The Item Construction service provides the different types of Items, defined in the Item Construction package: such as QTI Item, or some other forms, for example demonstration item. Every item has been assigned (one or more) Indicator(s) of the trait of the assessed concrete indi-vidual person(s) or group(s). In order to extend the functionality of the Item, Hint and Feedback are included.

Assessment Run-Time Service (ART)

The run-time service will be responsible for the assessment run and grading, resulting in providing rates and evaluation reports.

Functional requirements of the system

We defined the following functional requirements for each of the services:

Assessment Design Service (ADS)

The ADS must possess certain capabilities to support the assessment design process:

- To support activities related to the creation and support of a digital repository with assessment materials such as Assessment Scenarios and Assessment Plans.
- To supply a tool for creating, editing and deleting of an Assessment Plan.
- To supply a tool for creating, editing and

de-leting of an Assessment Scenario.
- To search the assessment plans and assessment scenarios.
- To define Traits: elementary and complex.
- To allow XML for data exchange.

Assessment Construction Service (ACS)

The ACS must possess certain capabilities to support the assessment construction process:
- To support activities related to the creation and support of a digital repository with assessment materials as Unit of Assessment.
- To search for a Unit of Assessment.
- To supply a tool for creating, editing and deleting of a Unit of Assessment.
- To supply a tool for creating, editing and deleting of a Scale.
- To add or remove Items.
- To allow XML for data exchange.

Item Construction Service (ICS)

The ICS must possess certain capabilities to sup-port the item construction process:
- To support activities related to the creation and support of a digital repository with assessment materials as Items.
- To search Items.
- To supply a tool for creating, editing and deleting of for Items.
- To define Hint, Feedback, Prompt, Case Text.
- To select the set of possible responses according to the chosen Response-type.
- To allow XML for data exchange.

Assessment Run-Time Service (ARTS)

- To allow defining of the parameters for Unit of Assessment and their type as self-learning, self-control, peer assessment, 360 degree feedback, etc.
- The sub-system must register the results from some of the Unit of Assessment.
- The activities related to filling the items must provide opportunity to set the type of the answers (for example yes/no, 1/0, many-from-many, matching, graphics, etc.)
- The system has to provide opportunity for development of a Unit of Assessment based on a database of items.
- A unit of Assessment can provide access at different stages and types of exam (self-assessment, partial assessment, and full assessment).

This includes opportunities for a learner to:
- List all their Units of Assessment.
- View information about a Unit of Assessment and schedule.
- Evaluate a planned Unit of Assessment.
- Possibility to view (during the evaluation) the runtime information about evaluation process, such as estimated time, planned time, page information, assessment information (Assessment Session).
- Auto evaluation and auto feedback for some types of items.

Conclusions

The paper describes services defined in the design of SOA for an assessment model, according to the defined non-functional and functional requirements. All functions of the Assessment Model are modeled as services, which include purely business functions as well as system service functions. The other main issue is that all services are independent. They operate as “black boxes” and function by merely returning the results.

Acknowledgements

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E-portfolio Assessment System Architecture

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Abstract

This paper describes the software architecture for a system, which supports the non-traditional form of assessment namely e-portfolio. We started from assessment model analysis, a next general assessment model is designed. Then the model is adapted to a portfolio assessment type as non-traditional form of assessment. A portfolio assessment tool is designed, implemented and evaluated on that basis. The focus of the paper is the portfolio assessment tool design, described from three different points of view: use case view, logical view and implementation view. Based on these three views a software system was designed and implemented. Some implementation issues are discussed.

Keywords: *Use case view, logical view, implementation view, assessment model, e-portfolio, eclipse RCP, java*

Introduction

Some new forms of assessment which divert from the existing traditional forms (such as examinations and tests) have emerged with the development in the area of human abilities evaluation. These new forms have showed that they are helpful to evaluate the competence of a given human by assessing a number of feature competences. Such examples are the e-portfolio, 360 degrees feedback, peers assessment, etc.

The present work uses one of the new non-traditional forms of assessment (e-portfolio), which is difficult to achieve with existing software means. So analysis, design and implementation of such a tool or system will add value of the research of the assessment area. As a result such assessment type can be integrated in the entire process of assessment. Also, assessment integration must comply with the existing standards and specifications in the area – for example IMS specifications [1].

There are many definitions of e-portfolio, and one of them is that an electronic portfolio is a collection of electronic evidences assembled and managed by the user, generally published on the Web. An e-portfolio provides proof for the user's competence, and is a way of self-expression [2].

According to the IMS definition assessment ePortfolios are used to demonstrate achievement to some authority by comparing these evidences of the portfolio to the standards defined by that authority [3].

The paper begins by giving a general picture of design research: the methodology; then the architecture design description of system is presented. The architecture design is divided into three views, which are described in more details following Unified Modeling Language (UML) diagrams [4] - use case view, logical view and implementation view. The paper also makes notes on the implementation and evaluation of the tool; conclusions, benefits from work and plans for future.

Methodology

Fig. 1 presents the classical design of research [5].

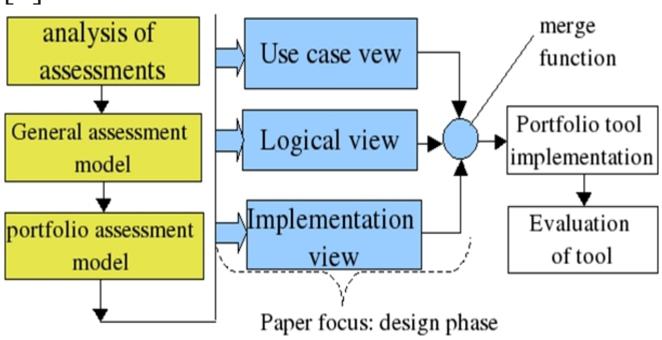

Figure 1: Research methodology of e-portfolio system.

The first three phases of the research are shown on the left of the figure. First is an analysis of the problem of the integration of the non-traditional forms of assessment into the classical ones. During the second phase the goal was to design an assessment model for general use to be applied to the assessment process. The third phase is verification: the model was evaluated. These three phases are not an issue of the paper. The fourth phase, which the current paper is focused on, is the design of the software architecture for system/tool which supports such kind of assessments. The system design description is presented via:

- **Use case view**: shows the main assessment process, defined by UML use case diagrams. These diagrams classify the primary cases that will be implemented and describe the sequence of the processes in the system for each user case.
- **Logical view**: presents the main classes and their interaction within the system, using another type of UML diagram – an analysis class diagram. The interaction between classes and objects is given from user's point of view: presented through descriptions, pictures and diagrams of the functionality instead of concrete classes.
- **Implementation view**: shows the system main components from the developer's point of view: through framework descriptions, and descriptions of significant classes. This is done through package diagram and physical package structure of system.

On the right (Fig. 1) the last two phases of the research are shown – implementation and evaluation of the system. These phases are also not point of the discussion here.

E-portfolio assessment system architecture

The subsections below discuss each of the views of the system design description.

1.1 Use case view of the system

Figure 2 presents the activities of the users and what they have to do to assess the portfolio by the designed software tool. The main user has access to the candidate's portfolio. The system supports assessment of the selected portfolio, and exports it to the external system or software.

The main scenario diagram to be discussed is "*Perform assessment*", which includes the score each assessment item has gained.

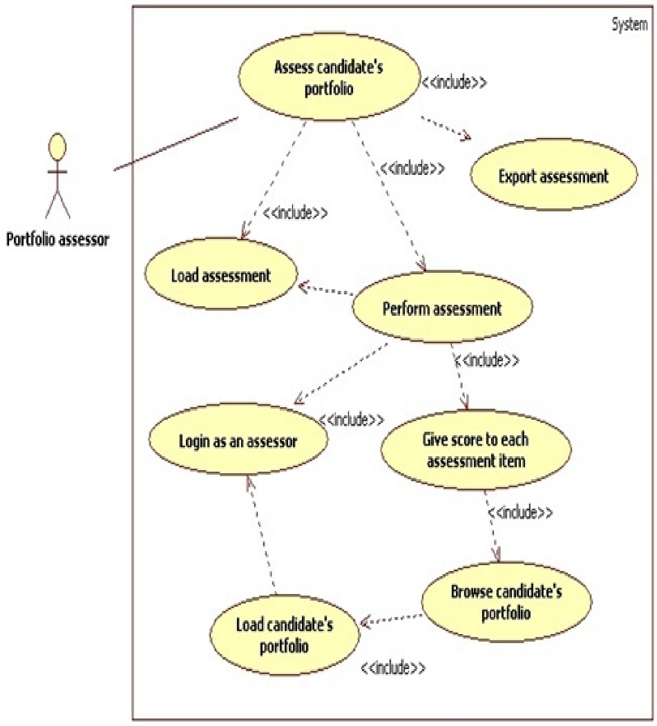

Figure 2: Use cases of the process of e-portfolio.

It includes eight use cases such as: assess candidate portfolio, perform assessment (main use case), give score to each assessment item, browse candidate portfolio, load candidate portfolio, login as assessor, load assessment, and save assessment. The names of the use cases are more or less self-explanatory.

1.2 Logical view of the system

The logical view consists of diagrams, containing classes and illustrating the system functions. Fig. 3 shows a translation from user concepts to system concepts on the one hand. On the other it can be seen the relation between the basic concepts, which are helpful to both developers and software architects.

The analysis class diagram represents the business-logic (fig. 3), which is based on the main scenario of the system. The analysis classes give concept view of the parts of the tool and help to understand its architecture.

There are two kinds of activities, related to the tool user - portfolio assessor. The main activity is the *Perform Assessment*, and the secondary - *Browse Portfolio*. The stages of these activities are presented on figure 3: the logical layers (or also flows) are horizontal, and the physical layers (or packages) are vertical.

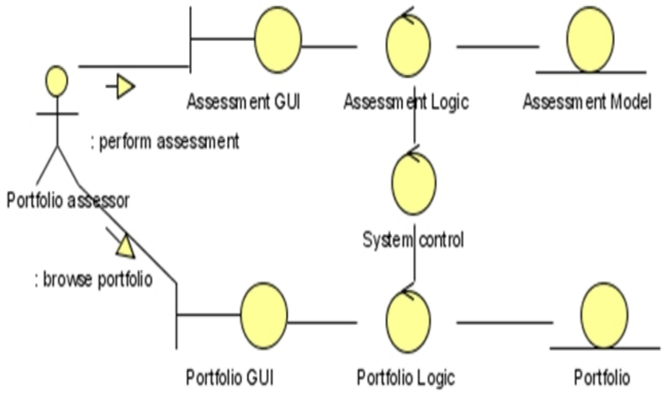

Figure 3: Analysis class diagram of the functionality of the system.

Both are described by boundary classes (the user interface), controller classes (business logic), and entity classes (data storage). Physical layers classes are for user interface – namely analysis classes *AssessmentGUI* from the main flow and *PortfolioGUI* from the secondary flow. Within these two flows we have controller logic analysis classes – respectively *AssessmentLogic* analysis class and *PortfolioLogic* analysis class. They are synchronized by *SystemControl*. Finally, the persistency layer is within the physical layer. *AssessmentModel* and *Portfolio* analysis classes are responsible for data storage.

The class analysis shows, that the system must contain at least two tools, which to be responsible for the different flows. Talking about a system, the tools can be viewed as separate modules from one integral system for portfolio assessment support. Despite the logical separation, we talk about a single system architecture in the end.

Fig. 4 shows the UML package diagram of the system. Its main aim is to describe the functionality of the application on the basis of a logical grouping. It organizes system elements into related groups to minimize dependencies between the packages.

The main packages represent: the assessment model, GUI, and the system business logic. The latter holds utility classes used in development.

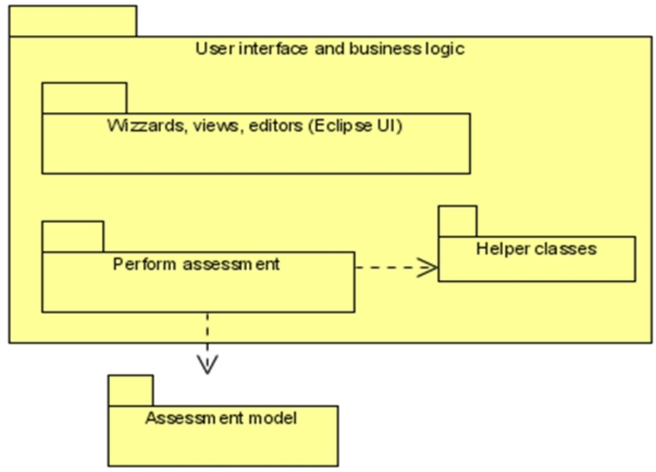

Figure 4: Package diagram of the system's functionality.

For example, eclipse environment [6] is used for development of the graphic interface, stored classes are needed for creation of wizards, views and editors and API for SWT and JFace components.

1.3 Implementation view of the system

This application contains several packages [7], grouped in a project, which contain the model implementation in the form of java classes. The names and structure of these classes are defined in the xml schema of the model.

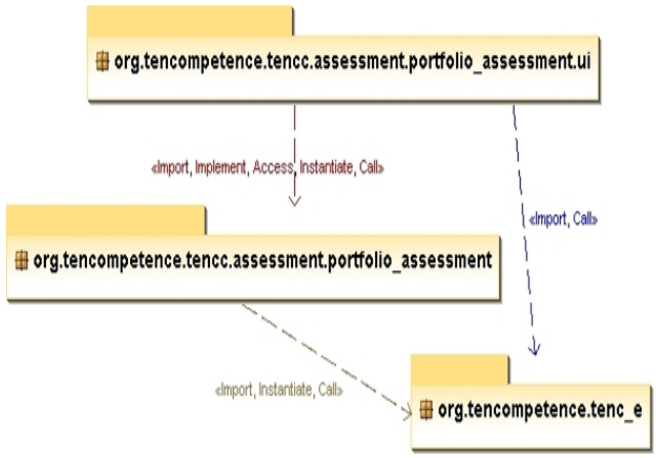

Figure 5: Package structure of the application.

There are two types of classes – on the one hand there are the classes, which are part of the business-logic of the application, and on the other hand – there are the purely technical classes for environment (framework) of the

Eclipse Rich Client Platform (RCP). The technical classes are:

- *Activator* (extends *AbstractUIPlugin*) – Eclipse plugin has a class connecting the project to the eclipse environment. The class provides callback methods, which can redefine the application to have access to specific events and resources of the environment. Typical methods are called by loading and unloading of software in plug-in by the Eclipse environment.
- *Application* – the Java class which controls the life cycle of the application. There is a similar function in the Activator; but the latter guarantee access to different type resources.
- The following three classes: *ApplicationActionBarAdvisor, ApplicationWorkbenchAdvisor* and *ApplicationWorkbenchWindowAdvisor*, are used to access resources and events in the Eclipse workbench. These classes manage the different parts of the environment, such as events, contextual menus, toolbars, etc.

The classes, which are part of the frame of the application, are divided into three groups:

- Comprehensive data models of the system – they are implemented through the class Model, which represent the logical organization of the system within the template design Model-View-Controller [8].
- Model Portfolio - implemented through classes PortfolioSection and PortfolioSubsection, which describe the structure of the portfolio as arranged set of files. The class PortfolioDAO, is used to extract portfolio from a database.
- Model of state of assessment - the different states which the application goes through durruning the runtime. It is the realization of the design patterns State and Observer [9]. It includes the classes PerformAssessmentSession, ISessionListener and an enumeration type SessionState.

Conclusions, limitations, benefits and future work

Based of these three views a system was designed and implemented. Fig. 6 shows a screenshot of the system.

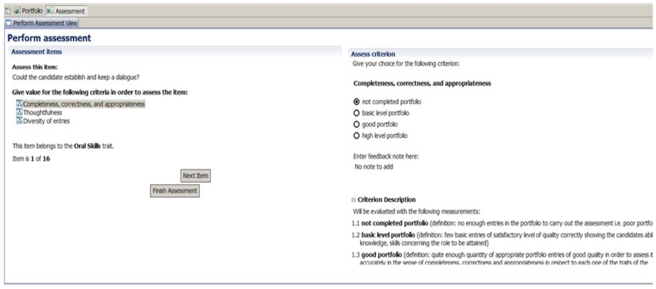

Figure 6: A screenshot from the proof-of-concept assessment player tool.

It has the capability to import and parse an xml file constructed according to the previously developed assessment specification [10]. It offers to its users to perform assessment activities according to assigned user roles. After the performance, it offers to the user to store the results using the same specification. This tool can also load the already performed assessment activities, and preview or evaluate results from the activities performed in the previous assessment run.

The evaluation of the system is carried out by black box testing on the basis of specially prepared evaluation samples. There are also unit tests to verify and evaluate model.

The system was evaluated and the results were satisfactory. The quality of the system could be improved, on the overall, however, it provides the necessary functionality to carry out the evaluation based on the TENCompetence Assessment Model.

In the process of system development the following key activities were performed:

- Research and analysis of problem areas.
- Definition of the system requirements.
- A module for developing and storing copies of the model was created. It includes the scheme itself, the source code generated by the scheme through JAXB technology [11], unit tests of the instance. The xml scheme developed

presents instances of the model. The items in this scheme satisfy the constraints of the model.

- Choice of technology for development – Eclipse RCP was selected as a target platform for development, JAXB technology for automatic code generation, and MySQL as a supporting database.
- Design, development, and test of the system – individual components were identified and developed.

As a conclusion it could be said that the designed and developed system, which is based only on one type of non-traditional assessment is limited. Nevertheless, the current research is a very important step of assessment modeling and assessment specification validation activities. The future work will include a wider adoption of other different methods of non-traditional assessment approaches.

Acknowledgements

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Using Widgets to Provide Portable Services for IMS Learning Design

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Abstract

Since the publication of the IMS LD specification it has been recognised that the lack of a rich set of runtime services is a major barrier to adoption. The approaches taken to resolving this problem are reviewed, and their strengths and limitations identified. A generic widget server developed by the authors is described. Integration of the widget server with the IMS LD runtime system provides an extensible set of services. This has been demonstrated with the creation of widgets for forums, messaging, vote, and Google maps which are provided for users within the context of their role and activities in a Unit of Learning. Authoring and administration are described, showing how the system is both extensible and portable.

Keywords: *IMS Learning Design, interoperability, integration, widget, portable services*

1. The problem addressed

IMS Learning Design (IMS-LD) is a specification developed by IMS Global Learning Inc [1] which enables users to implement learning activities for multiple users while maintaining the flexibility to define a wide range of pedagogical structures, and run them on any compliant application. A comprehensive introduction to the specification is available in Koper [2]. As discussed in Griffiths and Liber [3], IMS-LD has in some respects not achieved the levels of adoption which were initially anticipated. One reason for this is that the ability of IMS-LD players to orchestrate runtime services has so far been extremely limited. This problem was recognised when the specification was developed, as recognised by Olivier, one of the authors of the specification [4], p.38:

> Clearly many more services could be added to the LD specification, and it is desirable that they should be, from chat, instant messaging and white boards, through virtual classrooms and more sophisticated collaborative services, such as virtual design environments, to sophisticated simulation and multi-user game-playing systems.
>
> The key issue that needs to be addressed is how to add services in such a way that key learning designs that use them still retain a reasonable degree of portability across different LD-compliant platforms. If all the above services were included, could any system be expected to be compliant? Or should the specification stick to the lowest common denominator for services...?

IMS-LD does not define the actual services for use within a learning context, such as a wiki or forum. Rather, it specifies a small subset of four generic service types that could be used within a learning context:

- Conference
- Monitor
- Send Mail
- Index Search

Consequently the question arises of how the design is to be realised in runtime software. Most interestingly, what does a conference consist of? Is it voice chat, instant messaging, video conferencing or something else? What happens if I want to use service X in my Learning Design?

2. Some existing approaches to implementing services in IMS LD

Olivier and Tattersall also comment that "Learning services are likely to come in two varieties: those ... which are set up as part of a local environment; and those that are set up as remote web services" [4] p.39. These varieties are also termed tightly and loosely coupled scenarios,and systems to date have implemented the latterapproach. This was analysed by Tattersall et.al. [5] in relation to the integration of a SCORM player with IMS LD runtime, describing the use of a *Dispatcher* to direct resources to the appropriate runtime system. A system was implemented following this approach by the present authors, described by Sharples [6]. A similar approach was used by the developers of the SLeD LD Player to use Moodle as a provider of services. as announced in [7] using the approach described in [8], and demonstrated with an integration of the Moodle forum.

This approach provided effective integration for both SCORM and the Moodle forum, but did not provide a generalisable solution. Firstly, the effort involved in carrying out the integration was substantial, and the work needed to be repeated with each individual service to be integrated. Indeed Little [9], responsible for the Moodle forum integration, comments that many cases "you would probably want to link up sled to your own actual service providers (esp. for the forum)" and that this "would not be insignificant work". Secondly, it was not portable, indeed when a new version of Moodle was released the integration no longer worked, creating maintenance problems which appear to have been insurmountable.

Another approach is to build the player within an environment which makes a rich set of services available. This is the case for the IMS-LD player in the .LRN Virtual Learning Environment (VLE) [10]. In this case the player can directly map the IMS LD *asynchronous conference* service to the forum service available in the .LRN environment, and a similar solution is available for *sendmail*. This solution is effective, but not portable. It also ties the user to the set of services available within a particular VLE. as recognised by Escobedo et.al. [10] who describe how the inclusion of a chat service depends on its availability as a .LRN service.

Other systems have focused on tools for integration and management of services, and left possible integration with IMS LD for a later stage. This is the case of LAMS [11], which was 'inspired' by IMS LD, and which is able to export to IMS LD level A. However, while it provides a rich set of services and its own tools API, the information relating to the use of these tools in UOLs is stripped out on export to IMS LD, and so it does not provide a solution to the problem under discussion.

3. The solution developed

While these approaches to implementing services are satisfactory for their own purposes, none of them provide a solution to the problem identified by Olivier, i.e. the provision of a rich set of services in IMS LD while maintaining portability across different LD-compliant platforms. The solution proposed here was developed within the TENCompetence project, and centres on the development of an architecture which supports collaborative widgets, integrated into the existing IMS-LD infrastructure. This loosely coupled system, is both portable and extensible. We have developed a server implementing this approach, code-named Wookie, and have reported on its architecture [12] and implementation [13]. It should be noted, however, that although the widget server was developed with the needs of IMS-LD in mind, it has been created as an independent server, and integration has already been demonstrated in Elgg and Moodle. Here we focus on the use of this server to provide extensible and portable runtime services for IMS-LD.

4. Integration of the Widget Server with IMS-LD runtime

The Widget Server is responsible for providing a particular widget requested by the IMS Learning Design runtime system. Consequently the Widget Server needs to know, which specific widget to supply back to the running UOL. A solution to this was formulated whereby existing elements and attributes of the IMS Learning XML binding couldbe used to identify these specific widget services. For each IMS-LD service a *parameter* value can be specified. This may be any text an author wishes, but is usually a *name-value-pair*. To use one of the widgets made available from the widget server, a parameter must be added to an existing service element within an *environment* in a UOL. The name-value pair string to enter takes the following syntax, widget=<type of widget>. So for example, to use the default chat widget service, one would enter widget=chat. Similarly to use the default forum widget, one would enter widget=forum.

We focused on the use of the "Conference" service, since the "Monitor" and "IndexSearch" are IMS-LD specific in their use. "Send mail" is associated with an email service, but in theory this too could be realised by use of an email widget.

The realisation of the widget system working along side CopperCore and SLeD, meant that some other changes were needed in those systems. Firstly, a new service was needed within CCSI. This service is responsible for propagating the requests for a widget from the SLeD player, to the Widget Server. Additionally the SLeD player also needed to be updated, so that it could handle the *widget=context* parameter and hand it off to the new CCSI service.

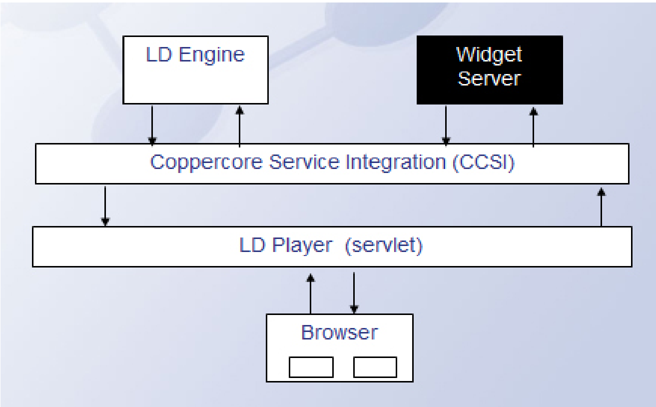

Figure 1: Integration of CCSI and Widget Service.

Finally, SLeD had to be able to parse the reply from the CCSI service and show each widget it found, in a draggable, resizable window. The solution chosen for this was to use Fenster[1] which is a cross browser Javascript windowing library.

5. The interaction cycle

The SLeD player provides the user interface for the Unit of Learning. When a user logs in they navigate around the UOL until a *service* is encountered within a particular environment. When SLeD obtains the environment information from the CopperCore engine, it first parses each service entry found, to see if it contains any *widget=context* entries. If one is found, then the SLeD player builds a query. The query contains information which is specific to the run, environment, service and user who is requesting the widget. Next, SLeD passes the query to the CCSI widget service, which in turn calls the Widget Server. The Widget Server then uses these parameters to either return an existing widget instance (an instance which has been used before) or create a new widget instance. The CCSI widget module takes an xml response returned by the Widget Server and passes those values back to SLeD. The SLeD player can now translate this information into the user interface. For example, returned values contain the URL of where the widget can be found and the widgets height and width to be displayed. SLeD now creates a Fenster window instance in the browser. Ultimately, once the user clicks on the widget link in the browser, a pop up window appears containing the widget content.

6. The extensibility of the Widget services

The Widget Server has an administrative section where new widgets can be added by importing an archive package containing all of the widget's resources. The archive also contains a manifest called *config.xml*, which must conform to the W3C widget manifest format. Once successfully imported, the administrative user can assign and create widget contexts to the widget. The server can host a number of different widgets for the same service, and in order to support *portability* the administrator designates one of these as the *default* for a category of widget. For example, if a UOL specifies a particular chat widget which is not available on the runtime server, then the learner is provided with the default chat widget. The integrated TENCompetence IMS-LD runtime system ships with a

1 **For information about Fenster see: http://www.cross-browser.com/x/lib/view.php?s=xFenster**

number of default widgets, including chat, forum and vote.

Consideration was given to how widgets would be authored at design time. It was apparent that authors would have difficulty in remembering to enter the *widget=context* parameter manually at the design stage. Additionally, authors had no way of knowing which widgets were available to use from a given Widget Server. To overcome this, an advertising service was written into the Widget Server. An authoring tool can query the widget advert and provide the author with a list of available services. This link between Widget Service and authoring tool has been implemented within the TENCompetence IMS Learning Design authoring tool, ReCourse.

ReCourse utilises the widget advert within its *environments* editor. An item in the tools menu, can query a Widget Server, to see which widgets it can provide. ReCourse uses the results of the advert to show a graphical icon of the widget, which it places on the tools palette. The icon location is also part of the advert, as each widget has an associated icon. When an author wishes to use a widget, they simply drag and drop the widget icon from the palette onto the canvas. This creates the appropriate service within the Learning Design, with the *widget=context* parameter automatically set.

7. Conclusion

The system developed provides a solution to the problem set out by Olivier. It constitutes a framework for the implementation of an extensible set of services for IMS-LD, a means of managing and authoring them, and a basic set of default widgets. The system is currently being piloted within TENCompetence. The availability of this new functionality has implications for the way in which teachers and learners work with UOLs which we will examine in future publications.

Acknowledgement

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Developing the Personal Competence Manager Evaluation Work: 'EPIQ Business Demonstrator'

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Abstract

The paper presents the design of a business demonstrator that will take place at EPIQ Electronic Assembly Business Unit EPIQ-2 (BU EPIQ-2), Botevgrad, Bulgaria. The process of a business model development to supply TEN-Competence services (particularly Personal Competence Manager), within the BU EPIQ-2's training process will be supported by the team of the Technical University – Sofia Research & Development Laboratory "E-Learning Technologies and Standards". The aim of the business demonstrator is to develop a sustainable implementation of the TENCompetence concept and open source infrastructure at BU EPIQ-2 to support communities and individuals within the company to further develop their competences, by using distributed knowledge resources and learning units, routes/programmes, and activities, that are available online. The BU EPIQ-2 as a high technology business organisation needs to get more out of their engineers and specialists (more than 95) and in this time of increasing global competition it is now even more important to have motivated and talented employees to help meet the organization's goals and objectives. The BU EPIQ-2's business demonstrator will focus on 8 pre-defined key job positions: Project Engineer; Quality Support Engineer; Test Engineer; Process Engineer; Project Leader; Customer Service Representative; Procurement Specialist and Recruitment Specialist. The pilot will last from 01 Nov 2008 until 30 Jun 2009.

Keywords: *Personal Competence Manager, professional community, competence profile, competence development plan, knowledge management.*

1. Research Context

Worldwide competitive economy places new demands on individual workers and organisations: new activities, new technologies, new markets, changing jobs, etc. Individuals are permanently triggered to further develop their competences. We see a competence as the estimated ability of an actor to deal with some classes of critical events, problems or tasks that can occur in a certain situation/ecological niche. Competences are managed by people and organisations at many different levels in formal definitions, profiles, needs and development plans. The descriptions of these competences may be complex and extensive, and a person who wants to make sense of the overall picture at any given level of granularity is confronted with a demanding task. This task is even more complex if it involves more than one level. The concept of competence can bridge the world of education, training, knowledge management, human resource management and informal learning. The goal of the TENCompetence Personal Competence Manager (PCM) is to simplify such tasks, and so to make Life Long Learning more agile and effective, and more responsive to the needs of learners. The PCM (Fig.1) can be considered a new "product" or service type in the area of the individual leaner's competence development. TENCompetence will deliver several electronic products and services to the European market for use by European citizens who wish to manage their competences. The technology system consists of TENCompetence servers which manage the competence development information. A rich client has been developed which accesses the various TENComptence servers, and other services. This adds a presentation layer, and provides tools that the user can use to edit data on the servers. Contextualised communities chat and forum services are provided for all functionality.

Figure 1: High level overview of connected services.

The main research questions are related to:

- Relevance of TENCompetence for the *BU EPIQ-2* Demonstrator Pilot Context
- Identification of business benefits for the *BU EPIQ-2* per core use cases
- How to build a business model for the PCM implementation in a real business environment in order to unify the processes of representing competences, planning competence development programmes, and coordinating competence development networks, as well as facilitating competence development activities?

2. The Target SME

The domain of *BU EPIQ-2* has been chosen for the TENCompetence evaluation works "SME's Business Demonstrator" because it provides rich opportunities for testing the TENCompetence system. EPIQ (**http://www.epiq.com**) emerged as a group in 1998 and went public on NASDAQ Europe, but listed since October 2003 on EURONEXT Brussels. EPIQ accounts for 10 entities in 6 countries. The Group has currently companies in Belgium, Germany, France, Czech Republic, Bulgaria and Mexico. EPIQ plants have been certified in complete conformance to the requirements of ISO-9001, ISO-9002, ISO-14001, VALEO-1000, QS-9000 and/or TS-16949 standards. EPIQ designs and produces high-added-value electronics and electro-mechanical systems and subsystems, which are the control and operating components for end products in the consumer market. EPIQ manufactures, finishes and tests printed circuit boards and supply complete systems and subsystems. EPIQ also supplies the required engineering, research and development (R&D), and logistic management, including JIT and SILS supply. The *BU EPIQ-2*'s main activities are: Manual and automated assembly of electronic components on PCB, including SMD and automated insertion processing; Board testing: testing whether all components are present and whether the board shows the desired electrical behaviour; Module assembly: attaching the circuit board to other parts, such as plastic housing; Final functional test ; Plastic injection molding ; Chip on Board assembly; Development and manufacturing of plastic injection moulds; Development and manufacturing of factory automation equipment. *BU EPIQ-2* is located at Botevgrad, 60 km away from Sofia, Bulgaria. Quality certificates: ISO/TS 16949, ISO 14001.

The *BU EPIQ-2* domain is challenging in a number of ways, which provide rich opportunities for validating the TENCompetence concept and infrastructure in the Cycle 3 pilot "business demonstrators": (1) *BU EPIQ-2* has real and urgent need for competence management improvement; (2) A business demonstrator will involve the definition, development and management of an extensive and complex set of competences; (3) The competences required in the electronic industry are very complex and rapidly changing; (4) *BU EPIQ-2* professionals require highly flexible training opportunities; (5) There is a constant flow of employees, that need to be trained.

The company faces the following problems: (1) There is a lack of competence profiles. Job descriptions are available, but not a detailed and well structured competence catalogue; (2)

There is a lack of a competence development program; (3) The traditional topic-based onsite corporate training process is time-consuming and a better effectiveness is desired; (4) There is no centralized knowledge management system or a digital repository of learning resources available. Very detailed materials, instructions and training plans are available though.

BU EPIQ-2 as a high technology business unit needs to get more out of their employees, particularly of their engineers and specialists(more than 95), and in this time of increasing global competition it is now even more important to have motivated and talented employees to help meet the organization's goals and objectives.

The possible solutions include:

1. Creating a catalogue with clearly defined and measurable competence profiles within a community context, which allow mapping to competence development plans and training activities.
2. Development, use, monitoring and maintenance of competence frameworks for different professions
3. Creation, sharing, discovery and use of knowledge resources, learning activities and learning paths by individuals and teams
4. Assessment of competences
5. Establishing the TENCompetence open infrastructure (hardware and software)
6. Support of users to navigate through all available learning resources to build specific competences.

The development of a business model to supply TENCompetence services within the *BU EPIQ-2*'s training process will be supported by the team of the Technical University – Sofia Research & Development Laboratory "E-Learning Technologies and Standards".

3. Aim and Expectations

The aim of the business demonstrator is to develop a sustainable implementation of the TENCompetence concept and open source infrastructure at *BU EPIQ-2* to support communities and individuals within the company to further develop their competences, by using distributed knowledge resources and learning units, routes/programmes, and activities that are available online. It will lead to a shift towards more integration between living, learning and working, lifelong learning, self-directed learning and self-organization, production of knowledge instead of consumption, learning activities instead of learning objects, knowledge sharing in communities, more attention for informal learning, assessment of prior learning and competence assessment and more attention on personal and social factors.

4. PCM Use Cases and Business Benefits Identification

Identification and where possible, quantification of business benefits is needed to determine the added value for an organisation when implementing the TENCompetence use cases. To determine which use cases (Figure 2) would most benefit *BU EPIQ-2*, the appropriate business benefits were linked to the use cases.

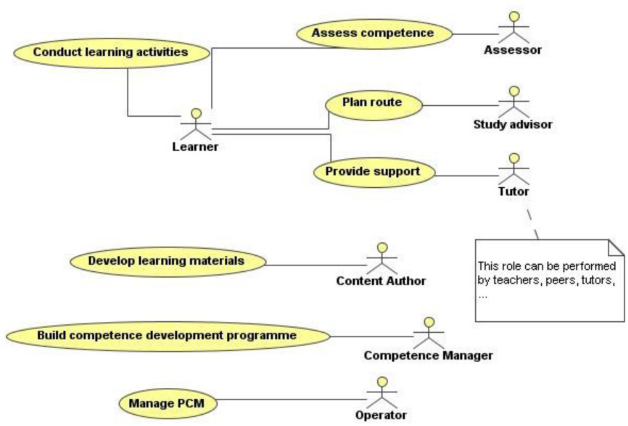

Figure 2:The seven PCM use cases.

<u>*Assess competence*</u> is the process whereby the learners' level of a competence is measured by an assessor, by assessing: the results of learning activities; the gap between the previously obtained and recognized competences and the desired competences; the competences to obtain, which are part of a competence development programme. Methods for assessment of competences can vary from several forms of performance assessment such as, peer assessment, self-assessment, portfolio assessment,

360 degree assessment etc., combined with the more traditional forms of assessments such as multiple choice questions, fill in the blanks, and multiple response questions. All preparations, evaluation and reporting of results are part of the assessing competence use case.

The possible business benefits per Use Case *Assess competence* are: Internal management, Process improvement, Personnel or HR management, Risk reduction, Flexibility, Economy and Strategic fit.

Build Competence Development programme presents the learner with the set of learning activities which he or she has to perform to attain the competences for a certain function/ job/diploma. The competence development programme presents the learner with the whole list of learning activities to conduct in order to become e.g. a project manager, a master in psychology etc. A competence manager helps the learner to define the competences.

The possible business benefits per Use Case *Build Competence Development* programme are: Internal management, Process improvement, Personnel or HR management, Economy and Strategic fit.

Plan route presents the learner with the best possible sequence of learning activities in order to obtain a certain learning objective. The learner receives a roadmap by which he or she can navigate efficiently through the various learning activities. A study advisor can help the learner define the sequence of learning activities. The possible business benefits per Use Case Plan route are: Internal management, Process improvement, Personnel or HR management, and Flexibility.

Conducting learning activities means the actual undertaking of courses, lessons, e-Learning, traineeships (by a learner) or any other activity to achieve a certain learning objective (competence, skills, knowledge, and attitudes). Usually a learner conducts several learning activities to obtain a learning objective.

The *provision of support* helps the learners to conduct the learning activities. This support can take many forms, such as coach, tutor, helpdesk, peer assistant, FAQ's,support agents etc.

The possible business benefits per Use Case *Provide support* are: Internal management, Process improvement, Risk reduction, Flexibility, Economy and Strategic fit.

Develop Learning materials. These are all the materials needed by a learner to learn. These materials include books, articles, HTML pages and computer programmes among others. The development of learning materials is supported as is the need to find appropriate learning materials in knowledge management (learning objects) repositories. The learning materials are usually developed by content authors.

The possible business benefits per Use Case *Develop Learning materials* are: Internal management, Process improvement, Economy and Flexibility.

Manage PCM. The Personal Competence Manager (PCM) is the software package of the integrated TENCompetence system. All development work within TENCompetence adds to this, making it TENCompetence's primary software package. „Manage PCM' entails the management (installing, running and monitoring servers) and maintenance (installing software patches and updates) of the PCM software in order to provide a durable facility to end users. This work is usually done by an operator.

The possible business benefits per Use Case *Manage PCM* are: Process improvement and Flexibility.

In the most basic sense, a business model has been defined as the method of doing business by which a company can sustain itself - that is, generate revenue. The business model spells-out how a company makes money by specifying where it is positioned in the value chain (Rappa, 2006). The business benefits types are tangible and intangible and related to financial and nonfinancial objectives.

5. BU EPIQ-2's Business Demonstrator Building Process

Competence management methodology offers a strategy and approach to work structurally on the development of employee competencies in order to increase the performance of the organization. It can help company to direct the changes in line with the organization's vision, mission and strategic objectives - whether the organization wants to exclusively enhance its performance, or transform its way of doing business. Competence management methodology is a strategy that consists of several steps to help ensure successful adoption of the new skills and competencies and the integration of the norms and values in the daily work activities of the employees.

Step 1: Develop competence management strategy. In general, most organizations develop a competence strategy to support the development of their professionals. *BU EPIQ-2* will determine the available time for identification of the competencies and the required resources for the implementation of the competence management strategy.

Step 2: Define competence profiles. After extensive research, a competence profile for all positions within the organization will be made. The competence profile is an elaborate profile of a function, which consists of a set of competencies and a competence definition and the observable behaviours for each profile as well as the required competence proficiency and priority level. Also, *BU EPIQ-2* will create a competence catalogue. In this catalogue all competencies with belonging definitions and observable behaviours will be outlined in categories. The process for doing the competence profile model requires some planning that includes the identification of existing core competencies, required competencies and the "gap". The competence dictionary (Figure 3), containing 30+ competencies from which the models will be developed, will be reviewed and modified.

Step 3: Validate competence profiles. The validation process is a feedback session in which *BU EPIQ-2* stakeholders and employees can indicate whether they agree with the competence profiles, definition and observable behaviours. Starting with the executive group is the ideal way to implement a competence system.

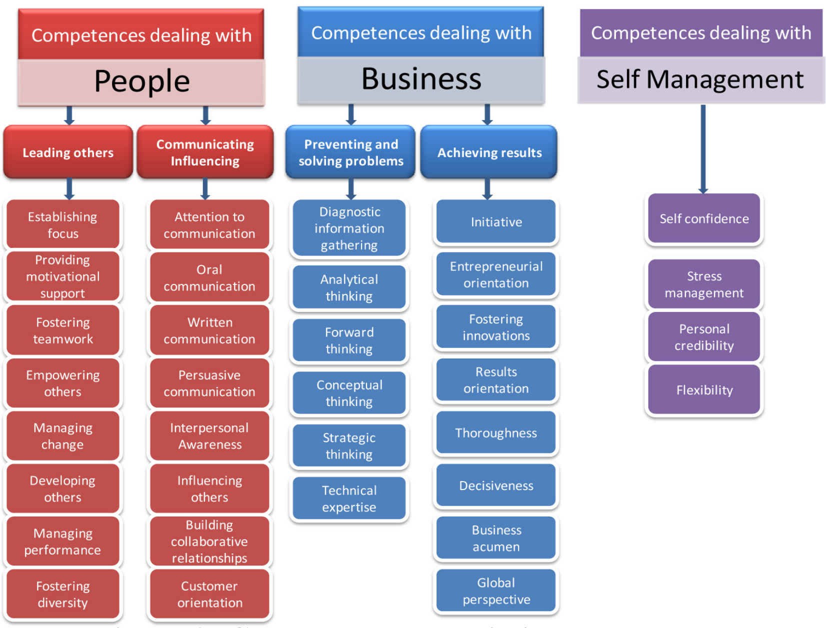

Figure 3: Core competence dictionary structure.

Actually going through the modelling process brings about understanding, ownership and commitment. Executives then see the competence system as a way to ensure that the right competencies are in place to carry out the business plan, and not just as a human resource activity.

Step 4: Build competence profile models. Develop competence frameworks for different professional communities.

A six-step model building process for the creation of the Business Demonstrator has been discussed and adopted (Figure 4).

The job competence model, as a description of those competencies possessed by the top performers in a specific job or job family, will be used for each of the EPIQ-2 EA demonstrator 8 pre-defined key-positions: Project

Engineer, Quality Support Engineer, Test Engineer, Process Engineer, Project Leader, Customer Service Representative, Procurement Specialist, and Recruitment Specialist.

6. Conclusion

The TENCompetence open infrastructure would be implemented at the *BU EPIQ-2* following the proposed process for the creation of the Business Demonstrator. TENCompetence concept and infrastructure are suitable to offer a variety of learning services, including knowledge capturing and sharing, self assessment tests, multi-level competence based learning offerings, etc. The company will re-define topic-driven training into competence based learning offerings. It will improve its human resources management through community networks, competence profile, competences, actions and resources.

Potential benefits for EPIQ-2 EA from the TENCompetence concept and infrastructure may include:

- Alignment of the EPIQ-2 EA strategic goals and objectives of the organization:

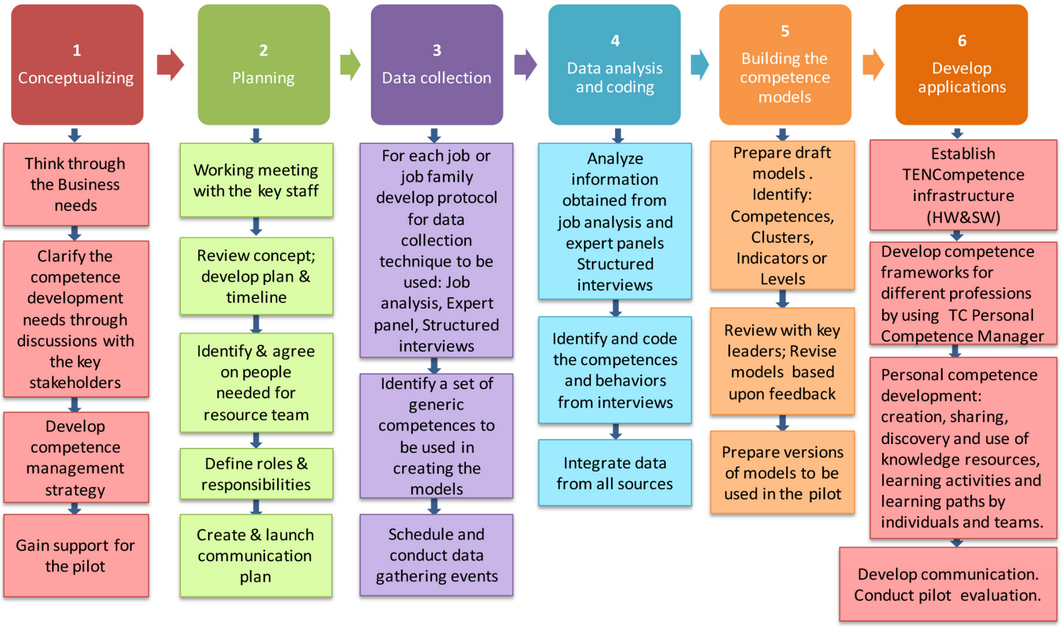

Figure 4: Building process for the creation of the Business Demonstrator model.

- Focus on the main processes within the organization
- Development efforts, which are focused to the direct development needs of the employees
- Increase performance level of the employees
- Create a culture of learning and continuous development
- Direct alignment with the EPIQ-2 EA competence management strategy, training and development plan
- Provision of support to organizational transformation and culture change.

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Web-service Architecture for Tools Supporting Lifelong e-Learning Platforms

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Abstract

It is widely recognized that modern European society needs adequate means for lifelong adapted access to facilities that support the creation, storage, use and exchange of formal and informal knowledge and learning resources. A key factor to achieve this is the adoption of Information and communication technologies and the work presented here reports on an approach involving the latest concepts of software engineering into lifelong learning solutions. The paper presents a reusable and extensible service-oriented architecture that supports implementation of different tools that support lifelong eLearning platforms.

Keywords: *Lifelong learning, Social Networks, SOA.*

1. Introduction

Currently, the European knowledge economy needs stimulation by providing ubiquitous and lifelong adapted access to facilities that support the creation, storage, use and exchange of formal and informal knowledge and learning resources. This aim also corresponds to the European agenda to stimulate lifelong learning as expressed in national and international policy documents. In the Commission's memorandum on Lifelong Learning [12] it is stated that: "Lifelong Learning is no longer just one aspect of education and training; it must become the guiding principle for provision and participation across the full continuum of learning contexts". As outlined in [1], lifelong learning refers to the activities that people perform throughout their life to improve their knowledge, skills and competence in a particular field, given some personal, societal or employment related motives.

It is widely accepted that lifelong learning should result in competences that are widely recognized and interoperable and should be adapted to take into account individual characteristics (preferences, needs, language, etc.). The use of Information and Communication Technologies (ICT) and more specifically, Internet, should be the key to achieving worldwide Lifelong competence development. To this end, there is a need for a better integration of existing learning and knowledge dissemination resources and activities. One possibility to involve the strengths of ICT in this process is to create and provide a framework for communication between people, based on similar learning development interests. Social networks are widely recognized as means for connecting people, based on their common preferences, goals and habits. Examples for popular social networks, that have a huge number of users registered, are myspace [17], facebook [14], hi5 [16], etc. Learning network is a very similar term to social network, representing a self-organized, distributed system, designed to facilitate lifelong learning in a particular knowledge domain [7, 8]. Usually learning network consists of:

- Users, i.e. lifelong learners, who are people with the intent to learn and the willingness to share their knowledge in the specified domain. Users may be grouped into different communities, according to their learning interests.
- Knowledge resources that represent collections of learning materials, activities and opportunities, that are created and shared in order to exchange knowledge and experience, or to develop competences in the domain.
- A set of defined learning outcomes, or 'goals' (competences and/or specific competence levels).

Research in the field has shown [4] that current e-learning and knowledge management environments provide limited support to the users in their various tasks. Also, there has been little unifying work which integrates models and tools for competence development during learning and working and across a lifetime. The TENCompetence integrated project [18], funded by the European Commission, provides valuable approaches for solving these problems, by offering specific models and approaches based on supporting users in their orientation in the social network [13]. In this paper we present a software solution aimed at providing reusable tools that support management and orientation of users within learning networks. We propose Service Oriented Architecture (SOA) framework for the implementation of the tools needed.

Next section of the paper describes the technologies used to implement the architecture. The framework and tools are described in section 3, followed by the concluding remarks section.

2. Technologies used

As a basic technological concept for our work we use Service-Oriented Software Engineering (SOSE), which is a contemporary paradigm in the area of software reuse. However, concepts and definitions are still somehow ambiguous. As stated in [2] service is a broad term that has different meanings depending on its usage context. For example, in computer science the terms of web-service, e-service and business service have common meaning. In this paper, we will focus on web-services (WS), which are broadly recognized [11] as: loosely coupled reusable software components that encapsulate discrete functionality and are distributed and programmatically accessible over standard Internet and XML-based protocols.

For building the SOA solution presented here we use the REpresentational State Transfer (REST) [5], which is an architectural style [6] aimed for distributed systems. REST is not strictly oriented to service-oriented systems, but still is very suitable for this purpose. It defines rules for how different resources should be identified and addressed, which is very similar to the classic web-service access protocols such as SOAP. REST does not rely on heavy additional meta-model layer, which is typical for SOAP.

Typically, REST regards all units in a system (this also includes system functionality and different states of its modules) or software application as a resource. This resource in turn may be accessed and modified via a Unique Resource Identifier (URI). For web-based systems, as World Wide Web, this URI is equivalent to typical URL (Universal Resource Locator), which is practically a web-address, accessible by any web-browser.

Besides REST we also use the multilayer client-server architectural style [10], which has proved itself as a successful solution for distributed systems. This way our architecture divides the data layer from the service layer (implemented as REST), as shown on Figure 1.

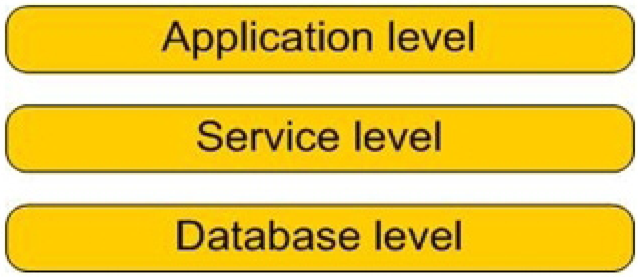

Figure 1: Basic three-layer architecture.

The database layer technology in use is Hibernate [3], is a popular open source object/relational mapping (ORM) tool. It offers transparent persistence for typical java objects and makes an abstraction over the classical SQL tables. This way the selected solution increases the reusability of the tools and more specifically the particular architecture, described in next section of the paper.

3. Web-service architecture

Tools presented in this paper are supposed to complement the life-long learning system, developed under the TenCompetence project. The core of this system is a server, that holds all relevant data about users, i.e. their profiles, preferences, competence development plans and etc. This server is called the Personal Competence Management (PCM) server.

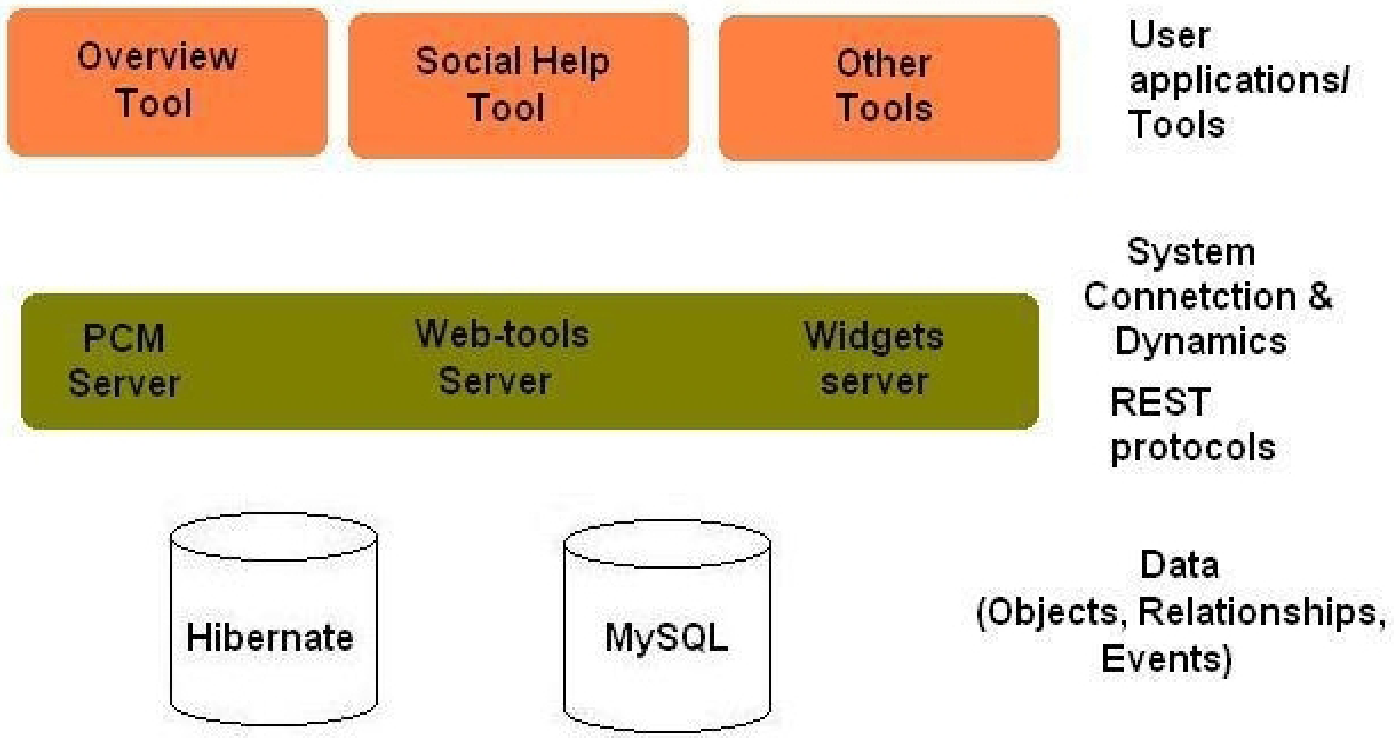

Figure 2: SOA architecture for lifelong learning systems.

As seen from the picture above, the proposed architecture supports multiple servers, which should fulfill the requirement that support REST. In fact, this is the original goal of TenCompetence project – to provide IT solutions based on open standards like REST. Based on the services provided by this architecture we have developed two particular tools, supporting the management of lifelong learning. These are the Overview Tool [4] and the Social Help System [9] (also known as Network Management Tool). The technology used for actual implementation of OVT is Adobe Flex [15].

In order to provide the framework for functioning of the tools described above, we have designed a database with several tables, supporting information about:

- users contacts
- users' best friends (also called buddies)
- personal data
- preffered types of learning resources

3.1 Overview Tool

The goal of the OverView Tool (OVT) is to enrich users' experience by providing data models which will allow more relevant matches between users to be made. It should also provide an integral overview of different Knowledge Resources (KR) that are available to users. In order to stimulate knowledge sharing and communication between people, it should also develop, test and integrate value-added components such as connection agents, simulation and game dynamics embedded in online competence development contexts.

OVT aims to provide an overview of all the possible formal and informal competence development programmes available. It consists of three main parts: Visualization maps, General browsing perspective and Linear browsing perspective. In order to simplify orientation of users for all available KR, they are divided in some categories and subcategories and the general browsing view of OVT gives an overview of all available categories of KR and also lists the subcategories of each category (Figure 3). Further users may explore possibilities for learning development by looking through all particular KR available that belong to a given subcategory. The visualization map gives a general overview perspective in terms of relations of the user with her/his competences (both acquired and desired) and her/his contacts and buddies. It also has the possibility to show the relation of the competence development plan of the user with available KR (learning resources and people over the learning network).

3.2 Social Help Tool

The main problem that motivates the implementation of Social Help Tool (SHT) is the critical necessity to reconsider and alleviate the load (or absence) of tutors and other academics staff needed to support the lifelong learners. The SHT aims to address the lack of individual experts and mentors in the learning networks. It provides users with opportunities to get help about a given learning topic from the learning network community (Figure 4). When the user asks her/his question the tool analyzes it and tries to find other learners from the community, who possess the competences needed to answer the question. After this step a discussion on the question may start either by e-mail or forum.

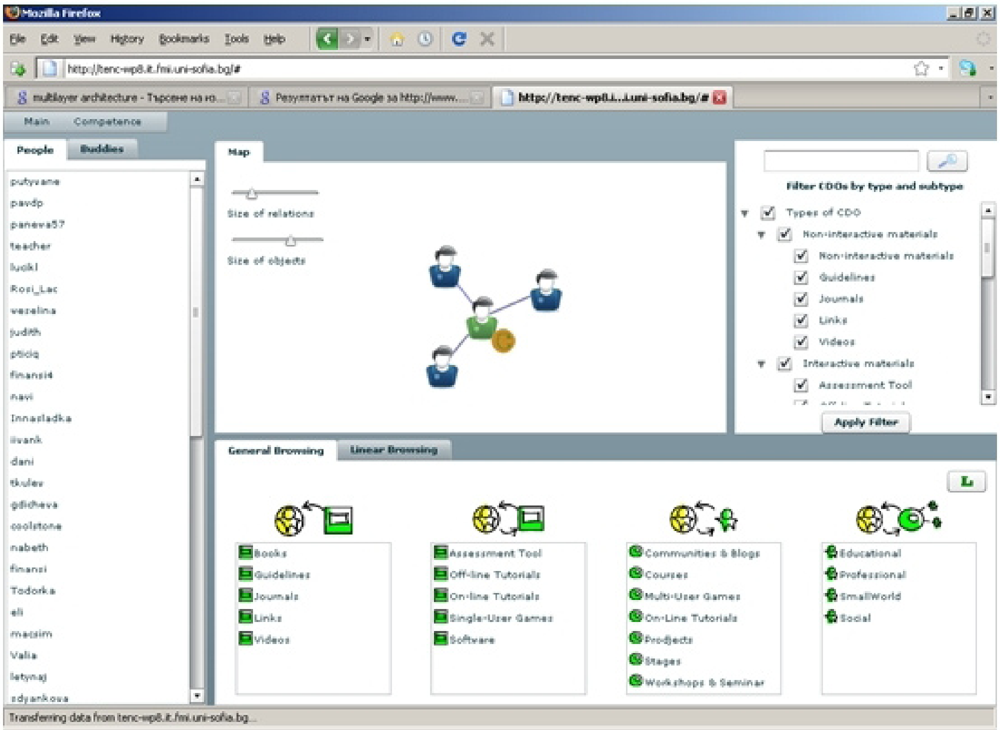

Figure 3: Overview Tool.

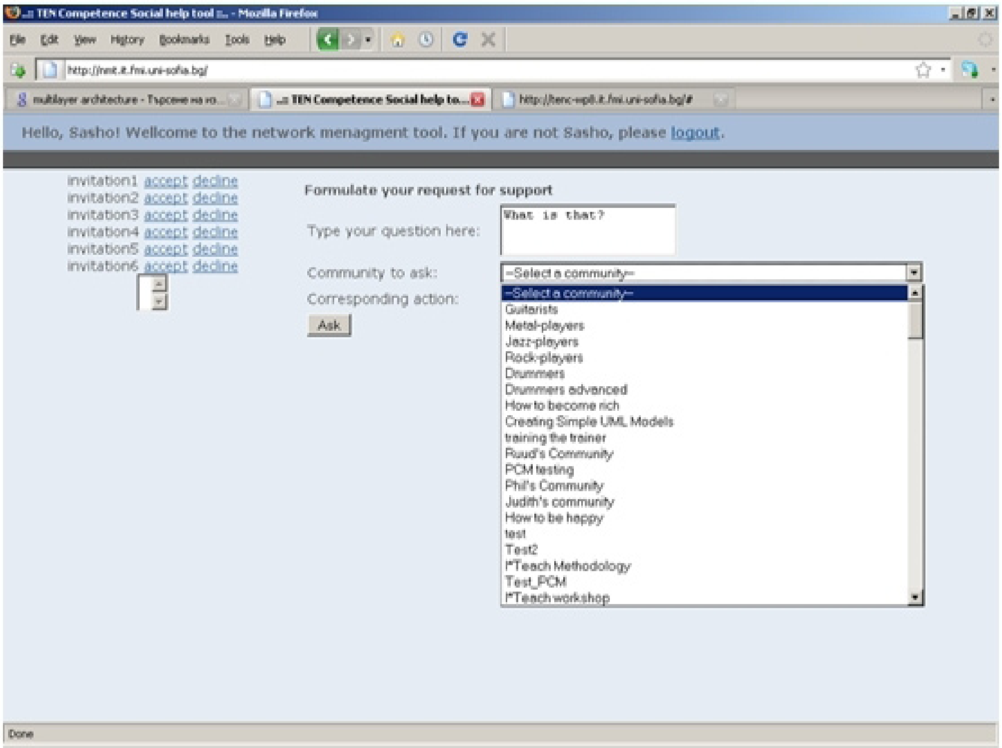

Figure 4: Social Help Tool.

4. Conclusion

The work reported in this paper presents an approach to build software tools that support the management of user activities within lifelong learning networks. A scalable distributed architecture based on REST services is developed for this purpose. It makes available integration of different servers that provide services for such tools and other client applications. Some modern technologies as Hibernate and Flex were used to implement the architecture and the Social Help and the Overview Tools presented in section 3 of the paper.

Our plans for future work include user evaluation of the tools and also improvement of their underlying models.

5. Acknowledgements

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An Analysis of Unreliability of Competence Information in Learning Networks and the First Exploration of a Possible Technical Solution

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Abstract

Automated competence tracking and management is crucial for an effective and efficient life-long competence development in learning networks. However, currently there is no objective method to represent, measure, and interpret competence. In this paper, we systematically analyze the problem of unreliability of competence information in learning networks. In tracking the development of competences in learning networks, a large amount of competence information can be gathered from diverse sources and diverse types of sources, which is subject to uncertainty and unreliable. This paper investigates information fusion technologies that may be applied to address the problem and that show promise as candidate solutions for achieving an improved estimate of competences by fusing (possibly inconsistent) information coming from multiple sources. This paper is intended to motivate educational technology researchers to learn more about information fusion, to perform studies with real and simulated data sets, and to apply in learning networks that may benefit from information fusion technologies.

1. Introduction

The advances of technologies enable self-directed learners to develop lifelong competences in learning networks (Koper et al., 2005). In order to support life-long competence development effectively and efficiently in learning networks, automatic competence tracking and management is crucial for determining learning goals, identifying competence gaps, seeking peers/partners, and offering appropriate learning opportunities.

However, tracking and management of competence is problematic. In theory, it is difficult to represent, measure, and interpret competence because competence is a very big subject complicated by very strong opinions and cultural traditions (Ostyn, 2005). In practice, no sufficient professionals serve for assessing competences of each lifelong learner in learning networks over time. As a non-expert in competence assessment, a lifelong learner may or may not evaluate a competence properly. In particular, somebody may intentionally not describe competences appropriately. As a consequence, the competence information captured in learning networks may be unreliable. The recommendations based on such unreliable competence information may be useless or make misleading. In this paper, we will systematically analyze the problem of the unreliability of competence information in learning networks and explore technical solutions to solve the problem.

2. The Problem of Unreliability of Competence Information in Learning Networks

In this section, we analyze why competence information captured in learning networks may be unreliable. Figure 1 illustrates competence-relevant components (including actor, object, and software agent) in a learning network, actual competence (represented in oval which is the target to be detected and tracked by the system), competence information (represented in light blue rectangle which including competence resource and competence record), their transformation (represented in arrow which are made by an actor or a software agent), and the main factors (illustrated beside the arrows) that influence the transformation. This section will explain in details.

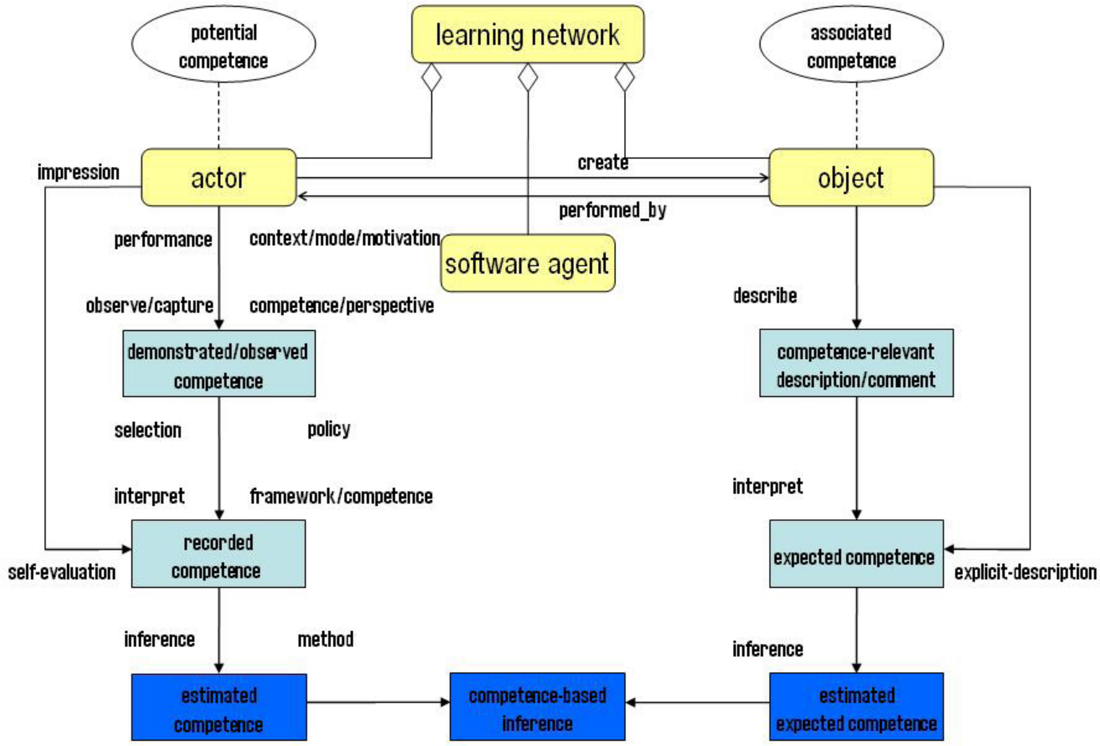

Figure 1: Competence information and transformation.

Competence is a latent attribute referring to an actor's (e.g., an individual, a team/group, or, an organization) underlying qualities and characteristics that lead to an effective performance. There is no systematic (objective) method to represent and measure potential competence like we represent and measure color and temperature. However, competence can be demonstrated and observed in a performance. The demonstrated competence can be captured as tangible source (as digital or non-digital evidence, which can be referenced persistently) or intangible source (as memory/impression, which can be recalled). In learning networks, various types of evidences can be captured such as a description of a performance (associated with a course, a task/activity, or a job), a product (e.g., an article, a design, and a response to a questionnaire), and an evaluation (e.g., a certificate, an evaluation of a response to a questionnaire, an analysis report of an article from a Latent Semantic Analysis (LSA) tool (van Bruggen et al., 2004)). It is important to note that evidence may or may not precisely reflect the potential competence. The competence owner may demonstrate a particular competence by performing tasks/activities with different characteristics under different situations (context) with different mode/motivation. On the one hand, the potential competence may be higher and lower than a performance or a product. On the other hand, a performance may or may not be precisely observed, recorded, and interpreted, because observers (or a software agent) may have different perspectives and measure methods and have different proficiency levels of necessary competences.

There may be a lot of evidences relevant to the same competence of an owner, which are originated from the same or/and different performances and captured by the same or/and different observers (or software agents). One or a set of evidences can be interpreted by actors (or software agents) as a competence record, which states that an actor has a known proficiency in a particular competence. For example, Sam's proficiency level of software development is "expert". However, the reliability of a competence record depends on which evidences are selected and how these evidences are interpreted. Various policies can be used to select evidences such as recent evidences, certain types of evidences, and the evidences provided by particular actors or software agents. In addition, various competence frameworks and criteria may be used to interpret evidences. That is, the proficiency levels of a competence and corresponding indicators may be defined differently. Different communities of practice may map the components and/or facets of a competence in different ways (e.g., different roll-up patterns and weighting patterns). In addition, even though in the same community, different people may have different interpretations to the same evidence. The same person may have different interpretations to the same evidence at different time, or as his relevant competences are improved. Note that a competence record may be created by oneself in a self-evaluation or by someone else based on memory, intangible source. In such cases, the reliability of competence records depends on whether the memory is good and how the impression is interpreted. That is, there will be a huge amount of competence records about each competence of the owner in a competence tracking and management system if it captures and stores all relevant information in a long period of time.

As shown in Figure 1, a certain object such as course, task/activity, or job is associated with certain required/target competences. Like the potential competences of actor, the associated-competences of the object can not be directly measured. However, it could be described as competence profiles as well. The problem is that different people may describe and interpret the same competence-relevant object differently. The competence profiles of a competence-relevant object may or may not be credible and trustworthy as well.

A competence tracking and management system can store all competence information such as competence evidences, competence records, and the relations to the owners, observers, interpreters, and the courses, tasks/activities, and jobs. They will be used to make judgments and inference. However, it is a challenge to produce an appropriate estimate of competence of an actor based on a huge amount of competence information, which may be inconsistent.

3. State of the Art

The problem of unreliability of competence information has not been sufficiently addressed currently. Ostyn (2005) explored to solve this problem by proposing a concept of distillation of competence information. According to his approach (see Figure 2), a confidence rating is introduced to qualify the competence evidence and competence record. The confidence rating is pre-determined according to a policy. For example, the results of a properly conducted 360 degree assessment are more credible than an assessment result from a supervisor, and in turn this result is more credible than that from a self-assessment or an online test on an unsecured computer somewhere on the Internet. The competence source or the competence record (called evidence record in the diagram) with the highest rating according to the policy will be selected as the competence estimate (called as competency record in the diagram) and other competence sources or the competence records will not be taken into account.

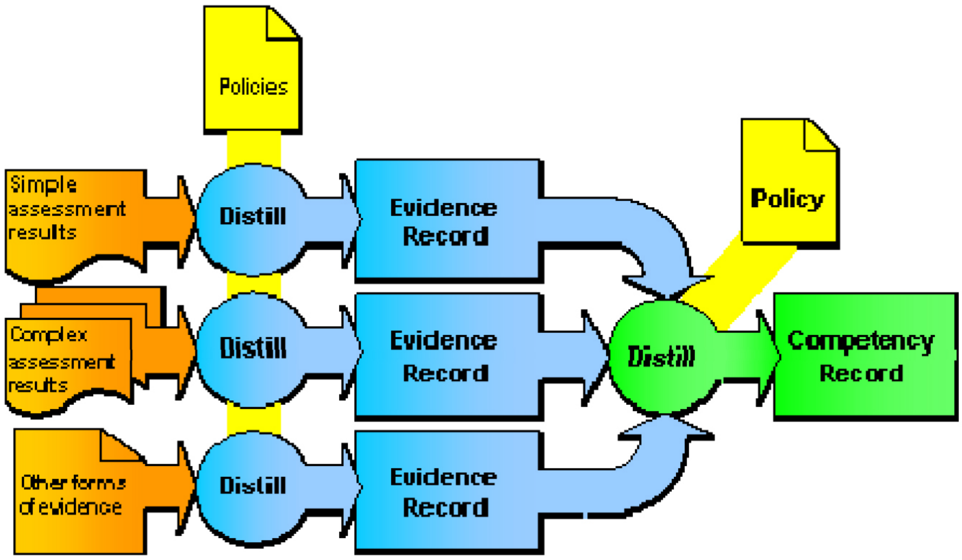

Figure 2: Summary of the competency evidence distillation process (taken from Ostyn 2005).

However, it is not true that a pre-defined policy is suitable for all cases. For example, sometimes a self-assessment is more credible than an assessment result of his supervisor. Therefore, this approach can not effectively solve the problems. In this paper, we will investigate whether an information fusion approach is suitable for solving this problem.

4. Introduction of Information Fusion

The concept of information fusion (or data fusion) is easy to understand and the operation of information fusion by itself is not new. As stated in (Wald, 2001), the human being has the capability to use multiple senses to percept the environment. Rich information is acquired from various sensory organs such as eyes, nose, month, ears, tongue, and hands. In addition, a man has redundant sensors. Two eyes have slightly different viewing angles, making possible stereo vision and depth perception. If one eye is disabled, vision is still possible, though in a degraded mode. The brain processes the acquired information using additional sources of information: its memory, its experience and its a priori knowledge. Calling upon its reasoning capabilities, the brain "fuses" all this available information to produce estimates about objects of interests, to assess situations, to make decisions, to update knowledge, and to direct actions.However, information fusion, as techniques, is relatively new. It is multi-disciplinary by essence and is at the crossing of several sciences. According to (Wald, 1998; Wald, 1999), information fusion is "a formal framework in which are expressed the means and tools for the alliance of data originating from multiple and diverse sources". Steinberg (2001) viewed information fusion as a process of combining data or information to estimate or predict entity states. The data range from numerical measurements to verbal reports. Some data cannot be quantified; their accuracy and reliability may be difficult to assess. Information fusion aims at achieving improved accuracies and more specific inferences that could not be achieved by the use of any single source alone (Hall & Llinas, 1997).

The information fusion offers some advantages (Waltz and Llinas, 1990):

- Robustness and reliability: The system is operational even if one or several sources of information are missing or malfunctioning,
- Extended coverage in space and time: The system can detect and trace the dynamic changes of the entities because a variety of distributed sensors can acquire information about the same entity at different time in different places,
- Improved confidence: The use of redundant and complementary information increases the certainty,
- Reduced ambiguity: More complete information provides better discrimination between available hypotheses,
- Providing a solution to process the vast amount available information for many complicated application systems.

The application of information fusion in technical systems requires mathematical and heuristic techniques from fields such as probability and statistics, Bayesian decision theory, plausibility theory, pattern recognition, fuzzy logic, neural network, expert systems, cognitive psychology, information theory, and decision theory. The functional application of information fusion is grounded in mathematical theory which is beyond the scope of this paper. The interested reader is referred to (Hall, 1992; Waltz, 1990; and Varshney, 95) for a detailed mathematical discussion. Information fusion is useful for several objectives such as detection, recognition, identification, tracking, change detection, and decision making. These objectives are encountered in many application domains such as defense, robotics, medicine, space, transportation, and weather forecast.

In order to have a better understanding of data fusion technologies, we brief introduce one of its applications in military with Wireless Sensor Networks (WSN), a special type of ad hoc network composed of a large number of nodes equipped with different sensor devices (Akyildiz et al., 2002; Nakamura et al., 2007). In comparison with large and powerful sensors, which are usually deployed in positions far from the battlefield and are definitely the targets being attacked by the opposing forces, the sensors in a WSN is small and inexpensive with limited sensing, computation, and communication ability. They are prone to failures and the information received from a single sensor may or may not be credible and trustworthy. They are different types of sensors such as seismic, low sampling rate magnetic, thermal, visual, infrared, acoustic sensors and radar, which are able to monitor a wide variety of ambient conditions. They can constantly monitor the status of friendly troops, the condition and the availability of the equipment and the ammunition in a battlefield. They can closely watch for the activities of the opposing forces and some valuable, detailed, and timely information about the opposing forces and terrain can be gathered. They can detect and track targets of the opposing forces (such as tanks, planes, and missiles) and can be incorporated into guidance systems of the intelligent ammunition. As the operations evolve and new operational plans are prepared, new sensor networks can be deployed anytime if necessary.

5. Competence Information Fusion

Generically speaking, some objectives such as detection, recognition, tracking, change detection, and decision making will be encountered to automatically track competence development in learning networks. Because of the limitation in size, this paper briefly analyzes similar characteristics of wireless sensor networks and learning networks from perspectives of application of information fusion technologies. Then we discuss one of important technical issues to solve the problem of unreliability.

In a wireless sensor network applying in military, the targets to be detected and tracked are objects such as tanks, planes, and missiles. An object has properties such as size, shape, and color and attributes such as position, direction, and velocity. There exist actual data if the object is moving in the battlefield. However, it is difficult to precisely measure the properties and attributes in the battlefield, where many factors (e.g., distance, perspective, bad natural conditions, and military operations) influence the measurement. In particular, the object may be with a designed shape, special material, and equipments to pretend and hide it from being detected. In a learning network, the object to be detected and tracked is the life-long learner with a set of competences. Each competence has an actual proficiency level at a given time. As mentioned, it is difficult to be precisely measured because many factors influence the accuracy of the competence records. In a wireless sensor network, a detected object is represented as a set of measurements, or attributes, or rules describing the object, completely or not. The goal is to produce an estimate of the values of properties and attributes, which are as closed as possible to the actual data, and then to make a correct judgment about the object. In a learning network, a competence profile is used to represent all competences. Each competence profile item can be represented as an estimate of competence. In a wireless sensor network, a sensor is a measurement device, and an imprecision value is usually associated with its observation. In addition, the sensing capability of a node is restricted to a limited region. Moreover, a given type of sensors can only perceive certain properties of the target. In a learning network, life-long learners and software agents (e.g., LSA tools and assessment simulators) measure competence. The capability of an agent (a human being or a tool) is restricted and different agents may have diverse abilities and bias. In a wireless sensor network, the data gathered by sensors are more or less credible and trustworthy. In order to overcome sensor failures, technological limitations, spatial and temporal coverage problems, multiple sensor nodes (with various types) will be deployed fully covering a region of interest. Each sensor obtains a partial view of a target under observation in a certain location at a certain time. These pieces of view can be fused into a continuously changed trace of the target. The redundant observations and measurements of multiple sensors can be fused to obtain more accurate data. Different types of sensors can perceive different properties of the target and the complementary information can be fused to produce a complete perception. In a learning network, a given competence can be evaluated by oneself, peers, experienced people, and software tools based on a certain performance from certain aspects at a certain time. There may or may not credible and trustworthy. As the actor works within a learning network for a period of time, massive competence information about the actor will be captured. Why don't we apply information fusion technologies to produce a more accurate estimate of the competence and to obtain a continuous trace of competence development by fusing all competence information in a learning network?

If we want to develop an automatic competence tracking and management system, we will face a formidable set of hurdles, all of which need to be taken. This paper discusses only one of important technical issues concerning the unreliability of competence information. In general, fusion requires appropriate weighting of information based on the quality of the source of the information. A credibility model is needed to characterize the quality of information based on the source and the circumstances under which the information is collected. In information gathering, it is necessary to rate separately the quality (reliability, degree of trustworthiness) of both the source that produces the record and the content of the record itself. In practice, if the source is judged 'unreliable', the record is essentially discarded. If the source is judged 'reliable', then the content of the record is evaluated to decide how much trust should be given to it. Usually, a computational model of the quality of the information is used to compare and analyze data by using prior information, evidence, and opportunities for learning from data. If the conflict is small, it means the record fits with previous opinions, and seems thus to reinforce them. If the conflict is large, it means that the content of the record clashes with the previous opinions. It is needed to find out the origin of the clash, and try to resolve it. For example, if it is proved that the record is created by one who trends to over grade certain competences or the record is originated from a performance, on which most records ware with lower ratings, the record will not be taken into account and the credibility of the actor and the performance will be re-assigned. However, if the record is produced by one, which is quite credible to assess this kind of competences, the credibility of the records and the sources which were used to develop the previous opinions will be re-checked. That is, the fusion process results in a revision or an update of the current belief function. Because there are very complicated inter-relationships among the competence information in a learning network, one change may trigger a sequence of changes.

A large variety of models and algorithms have been proposed in the literature to solve the problems. More models and algorithms will be developed in information fusion community. We feel that the problem in learning networks may be more complicated than that in traditional application domains because the "sensor" node is usually human being.

6. Summary

We systematically analyzed the problem of unreliability of competence information gathered in learning networks. In order to address the problem, we briefly introduced information fusion as a technique that may help us solve the problem we are bound to encounter once we implement automatic competence tracking and management in learning networks. We promote to launch research before information fusion can begin to deliver on this promise. We feel that a great deal of research is needed to introduce, implement, and leverage the concept of competence information fusion in order to make an organizational impact.

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The Effect of Adaptive Learning Style Scenarios on Learning Achievements

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Abstract

The study compare three adaptive learning style scenarios, namely matching, compensating and monitoring. Matching and compensating scenarios operate on a design-time mode, while monitoring applies a run-time adaptation mode. In addition, the study investigates the role of pre-assessment and embedded adaptation controls. To measure the effectiveness of different adaptive scenarios, a software application serving as a test-bed. was developed. The results of an experimental study indicated that the monitoring adaptation led to higher learning achievements when compare to matching and compensating adaptation, although no significant effect was found.

Keywords: *adaptive learning, adaptive software applications, learning style*

1. Adaptive software applications for educational purposes

The development of adaptive software applications for educational purposes has been dominated by instructional design solutions predominantly based upon level of knowledge (Corbalán-Pérez, Kester, & van Merriënboer, 2006; Kicken, Brand-Gruwel & van Merriënboer, 2008; Merrill, 2002; Oughton & Reed, 2000; Steele, 2003; Wisberg, 2003). Since recently, however, the adaptive software application paradigm has been experiencing a shift of interest to learning style as another important cognitive construct to take into account (Brown, Cristea, Stewart, & Brailsford, 2005; Gilbert & Han 1999; Merrill, 2002; Papanikolaou, Grigoriadou, Kornilakis, & Magoulas, 2003). Research on learning style has a relatively long standing tradition (see Jonassen & Grabowski, 1993; Riding & Reiner, 1997), but it has produced some contradictory findings, which need explanation in order to inform the design and development of adaptive software applications. The contrasting results can be defined as: (a) predictive effects of style on achievements (Martinsen, 1995; Martinsen & Kaufmann, 1999; Oughton & Reed, 2000) vs no predictive effects of style on achievements (Ayersman & von Minden, 1995; Kirton, 2003; Meneely & Portillo, 2005; Kommers et al., 2008; Steele, 2003; Stoyanov, 2001; Stoyanov & Kirschner, 2007); and (b) interaction effects between instructional methods and styles on achievements (Martinsen & Kaufmann, 1999) vs no interaction effect between treatment and style (Stoyanov, 2001; Kommers et al., 2008; Stoyanov & Kirschner, 2007). There are two groups of reasons that account for the contradiction in these research outcomes. The first one is related to the definition and conceptual operationalization of learning style as a cognitive construct. The second one is related to the definition and theoretical background of adaptive instruction.

1.1 Conceptual operationalization of learning style

Learning style can be defined as a stable pattern of individual cognitive functions and traits that determine the preferred way of approaching instructional stimuli.. Relatively recent conducted studies (Kirton, 2003; Kommers et al., 2008), within the contemporary learning style paradigm, have empirically validated a number of theoretical assumptions that can be used as a basis for the design and development of adaptive software applications. These assumptions are as follows:

1. A clear distinction should be made between style (in what way) and level (how much) classes cognitive constructs. Some examples of level types of constructs are abilities, knowledge, and competence. Level and style measures, if pure, correlate not at all. Learning style is non–pejorative construct. For example, reflector learning style is not better than activist, they are just different. Some instructional situations however could favor more a particular style than other.
2. Style has to be distinguished from process constructs (learning process or problem solving process) as well. At each stage of a process different styles can be identified, so can levels. Each stage can be executed at levels ranging from low to high and learning style ranging, from, let us say, activist to reflector.
3. Style and behavior could not necessary be in accord, or there could be a 'cognitive gap' between preferred behavior and observable behavior. People may happen to behave outside their prefer way of doing, a situation in which they apply the cognitive mechanism of coping behavior. They could be convinced or forced to learn in a way that is different from their learning style, as this way is considered to be more effective or socially desirable. People are capable to cope with such sort of situations but it is always at the expense of more efforts, energy and time. Flexibility of learning requires not only learning strategies that conform to a preferred style, but also a shift to less favorite learning styles, that are more effective in a particular situation.
4. A learning strategy, method or technique, can be learned to increase the level of performance directly, or to make more effective use of the available style as stimulating its strengths and compensating for its weakness.
5. Issues related to relevant operationalizion of learning style has affected the construction of measurement instruments for learning style. Many of them have low validity and reliability indicators (see Kolb's Learning Style Inventory –LSI, 1976; Felder-Silverman Index of Learning Styles - FS-ILS, 1988; Vermunt (1996).

1.2 Adaptive instruction based on learning style

Any attempt for an effective adaptive instructional design approach based upon learning style should take into account the advancement of the learning style theory, as discussed in the previous section. Adaptation has been associated with a purposeful effort for accommodating individual differences in learner characteristics for designing effective instruction (Jonasssen & Grabowski, 1993). Several instructional design adaptive approaches to accommodate learning style have been developed. *Preferential* adaptation (Jonassen & Grabowski, 1993; Stoyanov, 2001) implies that the instructional decisions take into account the strengths of a particular learning style. *Compensation* adaptation (Clark, 1983; Jonassen & Grabowski, 1993; Salomon, 1979) takes into account the weaknesses of a particular style to compensate for them.

Matching and compensation adaptation may include a *pre-assessment* (Jonassen & Grabowski, 1993; Stoyanov, 2001; Valley 1995) or an *embedded* adaptive control (Stoyanov, 2001; Valley 1995). Pre-assessment adaptation specifies learning paths of learners on the basis of filling out some instruments such as check-lists, tests, inventories, or questionnaires. Embedded adaptation accommodates learning styles through a particular way of structuring learning content: background information, examples, procedures and practice requirements. Learner's preferences can be implicitly identified through selecting the type and order of these instructional stimuli.

Pre-assessment and embedded adaptive controls can be part of either *design-time* adaptation (Gilbert & Han 1999; Stoyanov, 2001) or *run-time* adaptation modes (Brown, Cristea, Stewart, & Brailsford, 2005, Van Merriënboer

& Luursema, 1996, cited in Van Merriënboer, Clark, & Crock, 2002)). In the former mode all actions are predefined in advance. In the later mode, adaptation is realized through monitoring and tracking of students' behaviour using the inputs from either a pre-assessment or an embedded type of adaptive control. The technological development of adaptive instructional scenarios depends heavily on their conceptual design, that is how well they implement learning style adaptive models, modes and controls.

1.3 Technological implementations of adaptive approaches on learning styles

The most productive theoretical frameworks in which many projects in developing adaptive educational applications have been realized are Intelligent Tutoring Systems, Adaptive Educational Hypermedia, and Adaptive Educational Web-Based Systems (Brown at al, 2005; Papanicolaou et al., 2003; Specht & Kravcik, 2006). These frameworks represent actually one paradigm (Intelligent Educational Systems), which is built upon a common conceptual background that includes domain knowledge, expert model, student model, pedagogical model, and communication model. The most considerable contribution of this paradigm, perhaps, is the development of techniques for run-time adaptation. The systems that have been developed within the Intelligent Educational Systems paradigm made considerable progress in refining the properties of user models and promoting more advanced instructional techniques, but some important issues still remain to be addressed. The problems related to the definition of adaptation and conceptualization of learning style can be identified in the development of adaptive software applications within this paradigm. In some of the applications no distinction is made between knowledge, which is a level type of cognitive construct, and learning style, which is a preference type of cognitive construct (Brown at al., 2005). In other attempts, no difference is made between learning style and instructional strategy (Gilber & Han, 1999). Most of the systems implemented measurement instruments that had low validity and reliability indicators (see for example Brown et al., 2005; Papanicolaou et al., 2004). The current Adaptive Educational Hypermedia (AEH) projects tend to connect the instructional strategy to the learner model, but it is not always explicitly stated which specific instructional approach is used (Brown et al., 2005). When the instructional approach is specified, in the most of the cases, it does not reflect the current trends in modern instructional design theory and practice (see Papanicolaou et al., 2004). Sometimes the discussion on design approaches, based on learning styles, has been replaced by a discussion on learning style classifications (Brown at al., 2005). When the design approach for adaptation is explicitly referred to, typically it is the preferential type of adaptation, based on pre-assessment (Papanicolaou et al., 2004).

This paper is aimed at comparing matching, compensating and monitoring. adaptive scenarios based on learning style. Matching and compensating scenarios operate on a design-time mode, while monitoring applies a run-time adaptation mode. In addition, within the adaptive scenarios, the role of pre-assessment and embedded adaptation controls is a subject of investigation. The study explores the following research questions:

1. What is the effect of matching, compensating, and monitoring adaptive scenarios on complex learning?
2. Is there any effect of learning styles on learning achievements in complex learning situations?

To provide answers to these research questions, we developed a software application, which implements different adaptive scenarios including adaptive modes and controls. The tool is a test-bed for measuring the effectiveness of the adaptive scenarios.

2. Development of the tool

2.1 Architecture

The tool is a web-based application having two tiers and utilizing Microsoft technologies:

- Database server – MS SQL Server
- Web server – Internet Information Server
- Programming Technology – Active Server Pages 3.0
    - Server Side Script – VBScript
    - Client Side Script – JavaScript
    - XHTML, CSS, etc.

2.2 Typical usage scenarios

The order of logical arrangements of the tool when used by a student is as follows:

1. Register
2. Login
3. Read the tool and experiment overview
4. Fill in the Learning Styles Questionnaire
5. Learn the Case presented
6. Fill the Achievement Test for the Case
7. Submit any Assignments required

Figure 1 illustrates the implementation of the learning style questionnaire and the learning achievement test.

The student can also provide feedback for the tool usability at any time.

The main logical arrangement order of the tool during the usage by the administrator is as follows:

1. Login
2. Create Cases
3. Create Methods for each Case
4. Create Techniques for each Method
5. Populate the content for each Technique

    a. Activist Theory
    b. Activist Example
    c. Activist Procedure
    d. Reflector Theory
    e. Reflector Example
    f. Reflector Procedure

The administrator can also manage student accounts, review their feedback, learning styles questionnaire results and assignments submitted, and edit the tool and experiment overview content.

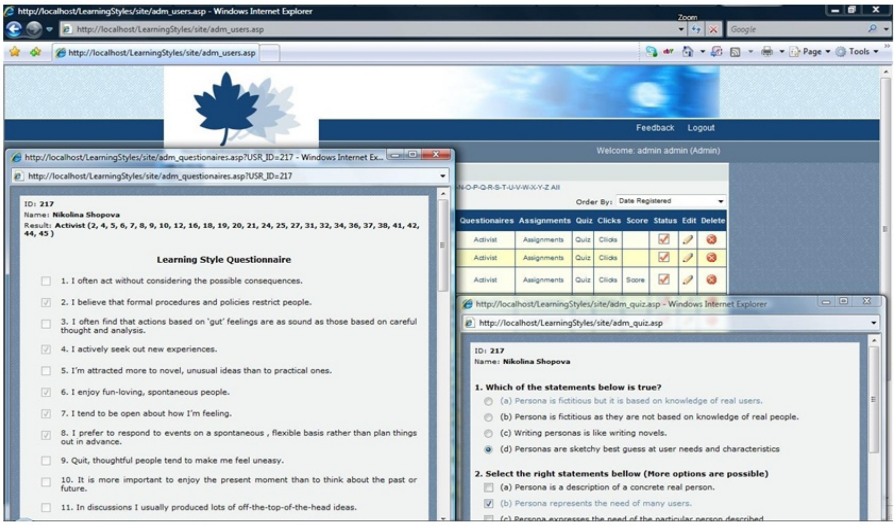

Figure 1: Fill in Learning Style Questionnaire and Achievement Test.

2.3 Tool Features

The most important features of the tool are: (a) automatic students allocation to an experimental group, that is support for an automatic assignment of students based on their learning styles questionnaire results and registration time in order to achieve equal split of the users with the same learning style (Activist or Reflector) among three predefined paths of structuring the learning content; and (b) run-time adaptation, that is support for run-time adaptation based on embedded adaptation control.

2.3.1 Automatic student allocation to an experimental group

In order to equally split the students having the same learning style across the experimental groups, there is a check for the current state of distribution as the student is allocated to the experimental group where the lowest number of students with the same learning style is. As there are three groups, it is clear, in one third of the times, which group has the lowest number of students with the same learning style, and in two third of the times there is a random selection between the groups where this number is equal. This algorithm allows equal split of the same learning style between the experimental groups, ensuring a distribution of an equal number of students in the three groups.

2.3.2 Run-time adaptation

The run-time adaptation is applied to the Monitor experimental group. Its design is based on tracking the student click stream and matching his/her behavior pattern to a predefined signature scores.

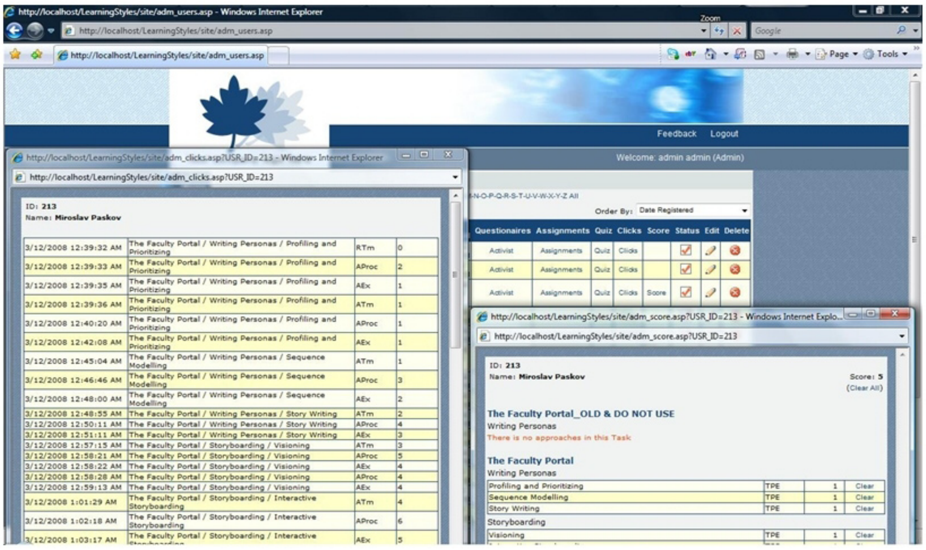

Figure 2: The student Click Stream and Score.

In this way the student already has a current score, which determines whether s/he is i.e. more Activist or Reflector and the system shows accordingly the learning content designed for this particular learning style.

There are 15 signatures possible, built upon a combination of the three different types of learning support, namely, theory, procedures and examples. The signature is formed based on the sequence of these types of supports, which the student visits when studying a particular learning content. The sum of all signatures for all learning content modules defines the student's current score and determines which content the system shows next. The score scale of the signatures is between -5 and 5 where the negative direction indicates the range of Reflector style and the positive direction indicates the range of Activist style. It means that a student with positive current score is assigned to the Activist content and a student with a negative current score is assigned to the Reflector content.

The time spent on a page is also tracked but it is not reported here. The plan is to enhance the run-time adaptation in the next release of the tool in order to build a more sophisticated scoring algorithm.

3. Method

3.1 Research Design

The research design of the study draws upon two research perspectives: (a) design research (Brown, 1992; Collins, Joseph, & Bielaczyc, 2004) or process research (Richey & Nelson, 1996) and (b) experimental research. Process research (design research) investigates the whole or the part of the process of design, development, and evaluation of a tool for educational or training purposes. A process research project addresses a context-specific problem situation to determine the characteristics of what is going to be developed along with attempting to understand and improve the design process and the designer problem solving by developing new tools and techniques.

Regarding the experimental research perspective, the study applies factorial experimental design. The independent variables are (a) adaptive instructional scenarios with three levels: matching, compensating and monitoring, on the one hand; and (b) learning style, on the other hand. The dependent variable is learning achievement of students. The two lines of research, (design) process research and experimental study, are complimentary to each other. The software application creates conditions for the experimental research. The results of the experimental study will be used for improving the software.

3.2 Participants and procedure

All the students following a master degree at a Faculty of Computer Science were invited to take part in the study. 216 students registered to the system. Of them, 152 filled out the learning style questionnaire and 49 did the learning achievement test. Only the participants who did the test are included in the analysis of this study. The participants had to study the software engineering technique called Writing Persona in the context of the case of designing and developing a faculty web portal. The students were randomly assigned to three groups. The learning content to study was the same for the three groups but it was structured in a different way.

The following heuristics have been used for structuring the learning content.

If the goal is to build a learning environment for the activist learning style, then involve the learner in a role-playing confronting her/him with a real life case (scenario, vignette) that has to be resolved. Describe the cast and the story.

If the goal is to support the learning experience of the activist learning style, then provide him/her with some heuristics for the systematic problem solving approach(s) to be applied to the case.

If the goal is to compensate for the weaknesses of the activist learning style, then present guided problems (modelling examples), war stories (work-out examples) and overview (theoretical models), preferably in this order.

If the goal is to support the reflector learning style, then present her/him with work-out examples, modelling examples and theoretical models, preferably in this order.

If the goal is to compensate for the weakness of the reflector learning style, then describe the real life context of the tasks, provide systematic problem solving approach(s), and ask for applying it on learning tasks.

One of the groups of students studied the learning content structured to match the preferences of the activist learning style. This learning track confronted the participants with a problem situation (designing a web portal) and involveed them in a sort of role-playing. The main supportive activity was providing guidelines and procedures. There were also guided problems and war stories, which were secondary supportive activities and were used as illustrations for the guidelines and procedures. A second supportive activity was a short theoretical introduction, which was provided at the beginning of the study. This learning path included in addition alternative guidelines, procedures, techniques and theoretical models.

Another group of students followed a learning track where the primary supportive activities were examples (work-out example and demonstrations). The secondary supportive activities were (a) procedures, guidelines and techniques; and (b) an overview of theoretical models. The participants assigned to this group were asked to provide a solution to a project scenario, which described the task of designing a web portal.

For the third group, the different types of instructional support such as theoretical models, examples, procedures, and guidelines, were available to learners for a selection. Depending on the selection made, the system offered consequently particular learning support (procedure, guidelines, examples, and theoretical models).

The students who accepted the invitation to take part in the study were instructed to register to the system. Once registered they got an access to a learning style questionnaire to be filled out. After that the system randomly assigned the participants to one of the three learning tracks as described. The learning content, structured to match the activist learning style, represented a preferential condition for the activists and a compensation condition for the reflectors. Similarly, the learning track designed to meet the needs of the reflector learning style was a preferential condition for reflectors and a compensation condition for the activists. The learning content structured for the activist and reflector learning styles operationalises the idea of design-time adaption based on pre-assessment adaptive control. The third group worked with a framework implementing the idea of run-time adaption based on embedded adaption control. The participants in the three groups followed the content in their own pace and at the end responded to an achievement test. The students were also encouraged to express their opinions on the content, adaptive approaches applied and the usability of the system.

3.3 Measurement Instruments

Two types of measurement instruments were used in this study: an achievement test and a learning style questionnaire.

The achievement test included 10 items to measure the level of knowledge and skills on the technique Writing Persona. The test applieed a context-dependent multiple-choice-multiple-answer format (testlets) with a vignette attached to some of the items. The reliability of the test reached a relatively high Cronbach alpha value (0.89).

The second measurement instrument was a revised version of the Honey-Mumford Learning Style Questionnaire (LSQ, 1992) for defining learning styles (De Ciantis & Kirton, 1996). The original LSQ has been widely applied, but some recent factor-analytical studies showed that it did not produce stable psychometrical performance (see De Siantis & Kirton, 1996). The four learning styles (Reflector, Theorist, Pragmatist, and Activist), which should be independent measures, actually form two orthogonal dimensions, each presenting a bipolar scale: Activist-Reflector and Theorist-Pragmatist (De Ciantis & Kirton, 1996).

As a result De Ciantis and Kirton created a new 45-items scale (.90 alpha). The Activist-Reflector scale is a pure 'style' type scale, which is appropriate for the purposes of the current study. The Theorist-Pragmatist scale seems to be problematic and unreliable and would not contribute substantially to the design blueprint and the measurement of learning styles. The modified LSQ was used for a first time. We hoped not only to reliably identify learning styles but also gradually to collect critical mass of data to validate the instrument and create norms.

3.4 Data Analysis and Results

The Levene test of homogeneity identified no violation of the analysis of variance's assumption, that the variance in the learning achievement test across the three groups is equal [F(5; 43,) = 1.4, p = .245].

A two-way between-groups analysis of variance (ANOVA) was conducted to explore the effect of the three adaptive scenarios, Preferential adaptation, Compensation adaptation and Monitoring, on learning achievements of the students. There was not a statistically significant main effect for groups working under different adaptive scenarios [F(2, 43) = .225, p = .800]. The mean score of the Monitor group

Adaptive Scenarios	Learning Styles	M	SD
Preferential	Activist	3.8	2.4
	Reflector	5.5	1.6
	Total	4.3	2.3
Compensation	Activist	4.6	1.3
	Reflector	4	2.8
	Total	4.5	1.5
Monitor	Activist	5.2	1.7
	Reflector	5	0.1
	Total	5.2	1.6

Note: Preferential scenario – 18 participants; Compensation scenario – 15; Monitor – 16.

Table 1: Mean figures and standard deviations for adaptive scenarios and learning style.

(M = 5.2) was higher than those of the Preferential adaptation group (M = 4.3) and the Compensation adaptation group (M = 4.5). Table 1 presents mean figures and standard deviations for adaptive scenarios and learning styles.

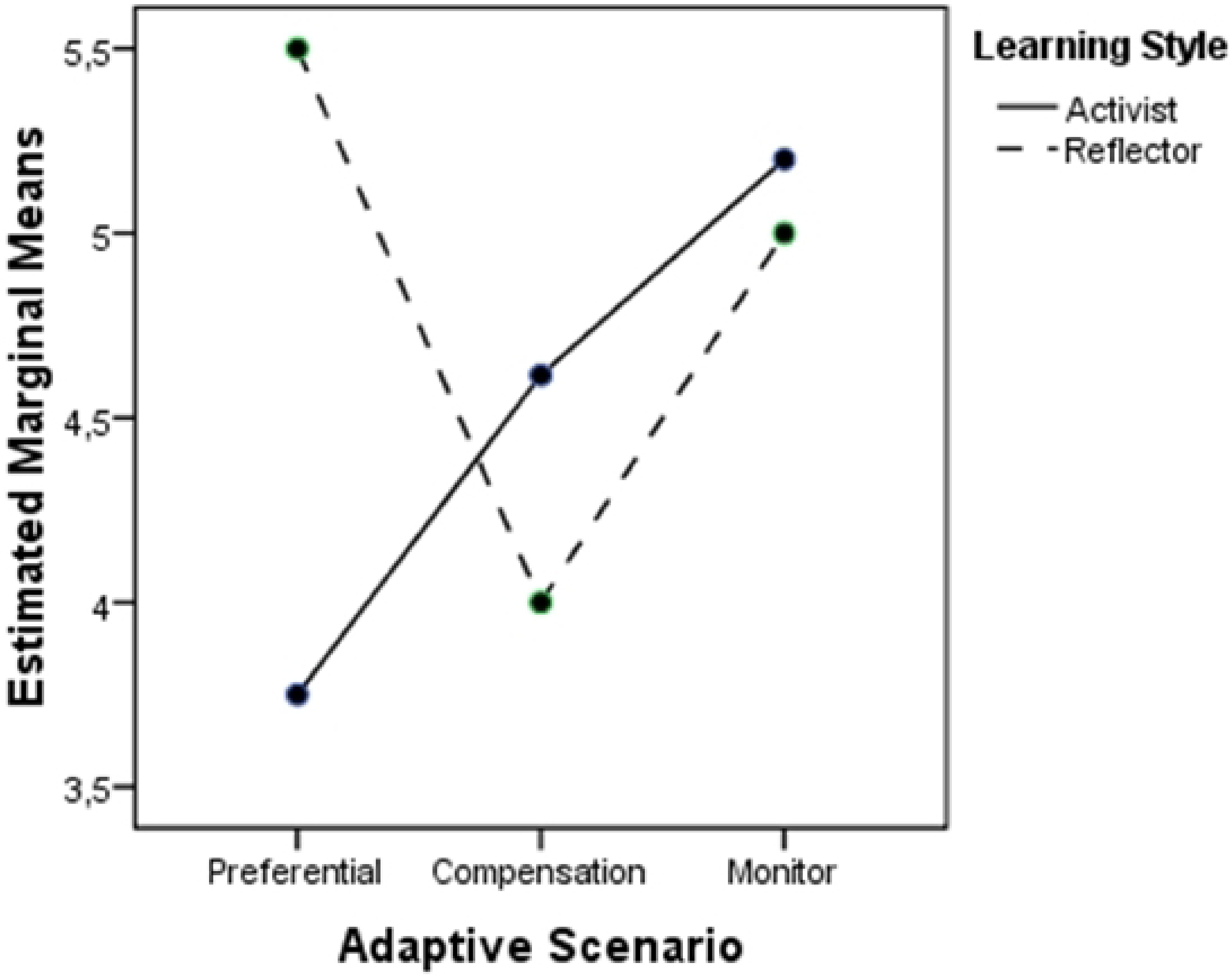

Figure 3: Interaction pattern of adaptive scenario and learning styles.

The main effect for learning style [F(1,43) = .135, p = .715] and interaction effect between adaptive scenarios and learning style [F(2, 43) = 1.168, p = .321] did not reach statistical significance. Figure 3 visualises the interaction pattern of adaptive scenarios and styles.

4. Discussion

Although no significant difference among the three adaptive scenarios was found, the Monitor group demonstrated higher results than the Preferential and Compensation scenarios. The students assigned to the Monitor scenario could select the types of resources they prefer (either guidelines, procedures and techniques, or examples and demonstrations, or theoretical models). Based on learners' selection, the system suggests the next learning activity and resources. The suggestions are based on preferential matching, that is supporting the strengths of a particular style, but there are also hints as how to overcome the weaknesses of this learning style. The Monitor group implementes the idea of embedded and implicit identification of learning style and it combines features of both the preferential and compensation adaption. The results of the study encourage further investigation of this approach for learning adaptation.

As it was expected, the study yielded no significant difference between learning styles. Learning style is about preferences of people, not about their level of knowledge, skills, or cognitive ability. People with a different level of capacity can be found within samples of different learning styles. In addition, even when put in a not preferable condition, people are capable to do what is required from them as they switch on the cognitive mechanism of coping behaviour (Kirton, 2003). Related to this, the current study brings some interesting ideas, worth to be further investigated. It seems that students with reflector learning style are more comfortable with the preferential adaptive instructional arrangements, while students with activist learning style deal better with the compensation adaption scenario. Reflectors showed a decrease of their learning achievements within the Monitor adaptive approach, while activists demonstrated an increase in their test scores (see Figure 3). Both style perform closely within the Monitor adaptive scenario.

The study sheds light on some issues related to learning adaption and its technological implementation as it also "open the door" for future research and development. The study, however, has some flaws from research methodology point of view. It would be useful to report on the effect of the adaptation scenario not only on learning achievements of students but also on their attitudes. How do students like adaptation approaches, and does learning style produce any difference among students in this respect? The satisfaction was included as a variable in the initial research plan, but we are not ready to report on it because we are still collecting data. The system also technically affords users to comment on different issue – content, adaptation approach, usability, and interface.

The sample of students is skewed toward the activist learning style, which means that activists and reflectors are not equally distributed across the three study groups.

Although the achievement test was equal for the three groups, and the Levene test indicated equally distributed variations of the test results, we suspect a 'floor' effect, which could explain the relatively low mean of the scores in the three groups.

Conclusions

This exploratory study was aimed at identifying some issues related to designing adaptive learning scenarios accommodating learning styles. The results will be used for attuning the research design and improving the software application, which we developed for the purposes of this study. We thought that building a prototype was the best way of operationalising theoretical constructs such as learning style, adaptive learning scenarios, modes and controls. The study confirmed our assumptions regarding learning style as a cognitive construct of preference type. Coping behaviour as a cognitive phenomenon provided a good explanation for the lack of difference in the performance of people with different learning style as well. The Monitor adaptive scenario, implementing the embedded adaptation control and run-time adaptation mode, seems a promising idea and need further investigations.

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A Formal Approach to Adaptive Content Delivery

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Abstract

In last decade there have been proposed a lot of works, systems and models in the area of adaptive e-learning. However, few of them have defined a formal model or give any formal description describing the adaptation process. This paper presents a formalization of an adaptation model for hypermedia learning courseware. The focus is on adaptive rules and adaptive process formal definition. There are described the main functions, constants and dependences providing adaptive e-content delivery. It is provided also explanation of the workflow of the adaptation engine. The benefits of this model formalization are good opportunities for analysis and assessment, design and implementation of a system based on it, and usage of the model of adaptation in other areas such as adaptive games.

Keywords: *hypermedia, learning object, learning metadata, learning platform, authoring tools, adaptive systems*

1. Introduction

Training is the most effective and successful when we have an interactive and collaborative process. It is inadequate to place learning materials in Internet. People expect the learning applications to delivery a highly personalized and contemporary content. A conventional hypertext system cannot provide this. This is a priority of adaptive systems. Therefore adaptive applications are increasing in popularity. They are entirely oriented to individual user's needs, preferences or knowledge [1]. The chief goal of personalized and adaptive e-learning was formulated by Wade in [2] as assuring of "e-learning content, activities and collaboration, adapted to the specific needs and influenced by specific preferences and context of the student, based on the sound pedagogic strategies". Adaptive Hypermedia Systems (AHS) propose various forms of adaptation, such as adaptive navigation, structural adaptation, adaptive presentation and historical adaptation [3]. Other of them focus on adaptability to learners' current knowledge based on the theory of knowledge spaces [4] or introduce additional level of system self adaptability based on the idea that different forms of learner model can be used to adapt content and links of hypermedia pages to given user [5].

There are only a few adaptive approaches that focus on their generalization and formalization. Several such models are for instance the Munich Reference Model [6], the Dexter Hypertext Reference Model [7], the Goldsmiths Adaptive Hypermedia Model (GAHM) [8].

This article presents formal description of a new approach for adaptive e-content delivery. It considers a model called triangle model of self-adaptive e-learning system which modifies its own behaviour (the learning process) in response to changes in learner input data and statistics gathered from previous teaching processes. The goal is to formalize adaptive process and to describe adaptive engine functionality by formal way.

2. A conceptual model of AHS

The AHS model described in details in [12] follows a metadata-driven approach, explicitly separating narrative storyboard from the content and adaptation engine (AE). Fig. 1 represents the triangular structure of our model which refines the AHAM reference model [9] by dividing in three each one of the learner's (or, generally speaking – user's), domain, and adaptation models. This is a new hierarchical organizational model for building adaptive hypermedia

Learning Management System (LMS). At first level, the model is based on a precise separation between learner, content and adaptation model, while at second level each of these sub-model is divided into three others submodels [10].

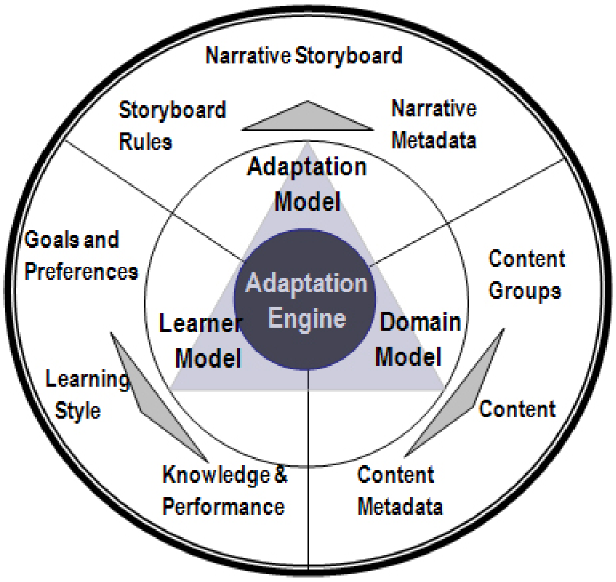

Figure 1: The triangular model structure.

Fig.1 represents the triangular structure of the model. Unlike other approaches, in the learner model we separate goals and preferences from shown knowledge and performance, as the first submodel is static while the second one is rather dynamic and takes a part in the event-driven storyboard monitoring. The model of learning style (learner characters such as visual, auditory, kinesthetic and others) is detached as another learner submodel and can be used for choosing contents for given learning style. While the learning style can be determined in the very beginning of the learning explicitly by the learner or by appropriate pretests, other tests should be exercised during the e-learning process in order to assess prior or gained knowledge and performance results of each individual student.

The domain model is composed of content itself (granulized in learning objects (LOs) according to the SCORM standard) [11], LO's metadata (LOM) and LO's content assets (images, text, tables, etc.) forming a logical taxonomy for the knowledge domain built upon domain ontology during the course composition process by the course author. The content LOs are placed by the instructor on course pages, while pages represent nodes within course storyboard graph. Content pages delivery is controlled by the adaptation engine (AE) for choosing most appropriate content for presenting it to the user with given learning model. Instead of choosing dynamically a page (i.e. node of the storyboard graph) with its content, we propose choice of best working path within the graph for specific learner with given learning style on one hand, and shown prior knowledge and performance on the other.

The adaptation model (AM) captures the semantics of the pedagogical strategy employed by a course and describes the selection logic and delivery of learning activities/concepts. AM includes a narrative storyboard submodel supporting course storyboard graphs, which may differ for different learning styles. It consists of control points (CP) and work paths (WP).

Moreover, AM should provide a schema of storyboard rules used for controlling the e-learning process. Storyboard rules determine sequencing of the course pages upon inputs from learner submodels. The narrative metadata submodel sets such rules for passing a CP (e.g., as threshold level of assessment performance at that CP) or for returning back to the previous CP.

The core of our model is the adaptation engine (AE) which is responsible for generating the actual adaptation outcomes by manipulating link anchors or fragments of the pages' content before sending the adapted pages to a browser. The AE uses an eventdriven mechanism for controlling the storyboard execution based on the storyboard rules applied to the inputs from the learner model. AE selects the best storyboard WP within the graph by evaluating weight coefficient of the pages within the WP for the given learner style [13].

3.Adaptive control over e-content delivery

The Adaptation Engine (AE) is responsible for performing all necessary adaptation mechanism for content delivery to a specific learner. This includes content selection, content hiding, link annotation, link hiding, etc.Fig. 2 represents the activity diagram of the AE. When learner starts a new course, adaptive engine finds the best path for him/her in the course graph. The best path is that one with the highest weighed score. For a particular user, the best path is calculated by a sum of multiplications between page parameters values and weights of their correspondent learner's characters. This path is stored for learner as current work path. When learner asks for the next page, adaptive engine may hide objects that are not important for this user. It may also select proper link annotations.

As many users are passing through the courses, adaptive engine has to remember user tracks. If a user abandons the work path determined by AE (by clicking on a link leading to another page outside of the path), the AE continues tracking pages the user has passed through giving the user ability to return back to the path by adding the link "Return to the WP" to each of the pages. As well, AE may store some statistics of learner feedbacks to determine which pages are useful for which kind of users. This gives the adaptation engine ability to learn from their skills and perform better estimations for paths for further learners.

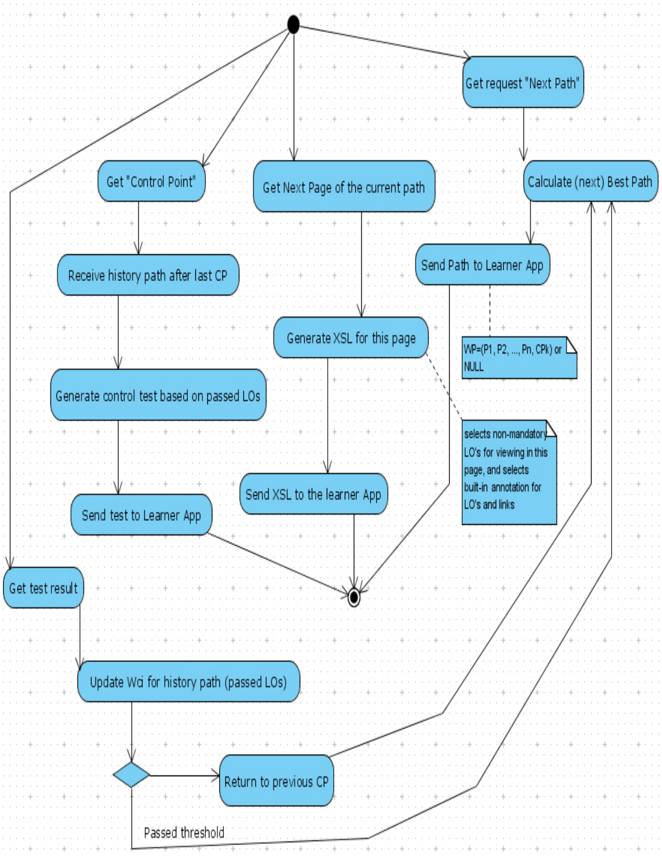

Figure 2: UML activity diagram of adaptive content delivery.

4. Formal specification of the triangle model

In this chapter we will give a formal description of adaptation process based on the triangle model.

For description of formal model can be used Object Constraint Language [14] like in the Munich Reference Model [6], descriptive language for specification like in GAHM [8] or predicate logic like in the Dexter Hypertext Reference Model [7]. In this paper for the formal model description will be used predicate logic.

Predicate logic [15] is extension of propositional logic with separate symbols for predicates, subjects and quantifiers. Its formulas contain variables which can be quantified. Predicate logic uses a wholly unambiguous formal language interpreted by mathematical structures. This enables for clearer adaptive process understanding and more precise adaptive rules description.

We claim that an adaptive hypermedia system can presents like a quadruple (LM, DM, AM, AE). Every element of it presents a submodel of the triangular model and its core - adaptive engine. For each of the items in the set (LM, DM, AM, AE) will be defined predicates that describe main functionalities of respective submodel:

- *LM* presents the learning model. For user's learning style can be defined at least three constants – visual, auditory, kinesthetic. The predicate that shows the level of belonging of a user to given learning style is:
    - *user_learning_style(user_id, learning_style, value)* where *learning_style={visual, auditory, kinaesthetic}*. Predicates representing knowledge and performance of the learner are as follows:
    - *user_knows_domain(user_id ,domain_id)* - it returns true if the user with identificator *user_id* knows domain with identificator *domain_id,*
    - *user_knows_subject(user_id, subject_id)* - it returns true if the user with identificator *user_id* knows subject with identificator *subject_id*,
    - *user_knows_learning_object(user_id,*

lo_id) - similar to the above predicates, it returns true if the user with identificator *user_id* knows learning object with identificator *lo_id*,
    - *user_performance(user_id, subject_id, control_point_id, value)* as *value={pass, fail, notReach}* – it presents the test result for a student with identificator *user_id* in control point *control_point_id* of the subject with identificator *subject_id*. The test result value can be *pass* if the student passes test in related control point successfully, can be *fail* else and *notReach* if the learner is not doing this test.
- DM defines predicates related with the domain model. This predicates can be divided into two groups. The first group presents hierarchical links in particular domain tree for example:
    - *domain_lo(domain_id, lo_id)* – it has value true if learning object with *lo_id* is contained in domain with *domain_id*,
    - *parent_lo(lo_parent_id, lo_child_id)* – it returns true if learning object with *lo_child_id* is child of learning object with *lo_parent_id* within a given domain tree,
    - *inheritor_lo(lo_main_id, lo_inheritor_id)* – this predicate receives value true if learning object *lo_inheritor_id* is at a lower level than learning object with *lo_main_id* and more *lo_inheritor_id* is inheritor of *lo_main_id* in a domain tree.

    The second group presents respectively that a particular test question belongs to a given learning object and the answers for a question together with its assessment points (*value*).
    - *test_question_lo(lo_id, test_question_id),*
    - *test_answers(test_question_id, answer_id, value)*
- AM includes predicates represent functionalities from the adaptation model. They describe respectively:
    - graph composition with following predicates:
        - *cp_path_4_graph(subject_id, path_id)* – it consists of all paths for particular subject and returns true if the path with *path_id* belongs to subject with *subject_id*,
        - *page_4_cp_path(path_id, page_id)* – it defines if the path with *path_id* contains the page with *page_id*,
        - *annotation_cp(learning_style, control_point_id, value)* – this predicate gives annotation (*value*) for a control point *control_point_id* in accordance with value of student learning style (*learning_style*) as *learning_style={visual, auditory, kinaesthetic}*.
    - subject content containing the predicates:
        - *lo_4_subject(subject_id, lo_id)* – it consists all learning objects for particular subject and returns true if the subject with *subject_id* contains the learning object with *lo_id*,
        - *lo_4_page(page_id, lo_id)* – it returns true if the page with *page_id* contains the learning object with *lo_id*
        - *control_point_4_subject(subject_id, control_point_id)* – similar to above predicate it consists all control points (*control_point_id*) for particular subject (*subject_id*).
    - page sequencing and page link annotation presented by relevant predicates:
        - *link_pages(current_page_id, next_page_id)*
        - *link_pages_annotation(learning_style, link_id, annotation)*
- AE defines predicates related to the triangular model core – adaptation engine:
    - *next_cp_path(user_id, subject_id, previous_cp_id)* – it defines the path for student with *user_id* to next control point
    - *sub_precondition(subject_new_id, subject_old_id)* – it describes precondi-tions or the courses (*subject_old_id*) that need to know to start a new subject *subject_new_id*.
    - *precondition_subject(subject_new_id)* – it returns true if all preconditions are realized.
    - *user_precondition(user_id, subject_id)* – it checks if user *user_id* is realized all necessary preconditions to start the subject with *subject_id*.

Once we have defined the predicates describing main functionalities of the triangle model we can begin giving adaptive rules. They can be presented by defining relationships between the predicates. The adaptive rules can be divided into three main groups in accordance to their purpose:

- starting rules - these rules describe learner knowledge and the initial conditions for starting a new course.
  If the user knows all learning objects contained in a domain/subject, then she/he knows that domain/subject – (1), (2):

(1) $\forall user_i\, \exists domain_j(\forall lo_k\, domain\_lo(domain_j, lo_k) \wedge user\_knows\_learning\_object(user_i, lo_k)) \rightarrow user\_knows\_domain(user_i, domain_j)$

(2) $\forall user_i\, \exists subject_j(\forall lo_k\, lo\_4\_subject(subject_j, lo_k) \wedge user\_knows\_learning\_object(user_i, lo_k)) \rightarrow user\_knows\_subject(user_i, subject_j)$

  If the learner knows all subjects, which participate in precondition for given subject, then the learner can start learning it – (3), (4):

(3) $\forall subject_j\, \exists user_i(user\_knows\_subject(user_i, subject_j) \wedge sub\_precondition(subject_k, subject_j)) \rightarrow user\_precondition(user_i, subject_k)$

(4) $\forall user_i(user\_precondition(user_i, subject_j)) \rightarrow next\_cp\_path(user_i, subject_j, null)$

- pass-through graph rules – consist of rules for the graph crawling.
  If the learner passes or not the test at a control point, she/he continues respectively forward (5) or backward (6):

(5) $\exists k(user\_performance(user_i, subject_j, control\_point_k, pass)) \rightarrow next\_cp\_path(user_i, subject_j, control\_point_k)$

(6) $\exists k(user\_performance(user_i, subject_j, control\_point_k, fail)) \rightarrow next\_cp\_path(user_i, subject_j, control\_point_{k-1})$

- rules updating learner model – this rules are related to learner knowledge and performance.
  If the learner passes all control point's tests for particular subject then the learner knows this subject – (7):

(7) $\forall k(user\_performance(user_i, subject_j, control\_point_k, pass)) \rightarrow user\_knows\_subject(user_i, subject_j)$

If the learner passes particular control point's test then she/he knows learning objects contained in the selected control point path – (8):

(8) $\forall k\, \exists i(user\_performance(user_i, subject_j, control\_point_k, pass) \wedge page\_4\_cp\_path(path_m, page_d) \wedge lo\_4\_page(page_d, lo_k) \rightarrow user\_knows\_learning\_object(user_i, lo_k)$

5. Evaluation design

In this chapter it would be presented a short plan for evaluation of the adaptive e-learning system following conceptual model explained in section 2 and implementing the adaptive rules defined over.

The purpose of this evaluation is to investigate the future system from several viewpoints concerning issues such as:

- adaptability
- usability
- learner's level of knowledge understandability

Each of the above mentioned aspects defines several questions on which the evaluation design is expected to meet.

There are two main questions relating to adaptability: first, whether the system will provide enough functionalities assuring adaptive content delivery to the learner and, second, whether the implementation is stable and allows an easy expansibility. These questions will receive their answers during the realization and testing. More, they will be made any necessary adjustments in order required conditions to be met.

After implementation and testing of the adaptive application are completed, it is planned to examine its usability. The aim is to establish whether the system provides intuitive and user-friendly interface with consistent structure. This will be found by interviews and discussions between the developer team and users (who belong to four types: learner, author, instructor and administrator).

Finally, learner's level of knowledge understandability will be studied. Therefore, it would be given a response whether the learner is satisfied with the way of presenting educational content and navigating in it, and if not

- where is the reason for this – in adaptability of the system, learning content, method of presentation or other. For this purpose, they will be prepared questionnaires, whose task will be to collect feedback from learners. The learners will be observed how long time spare for every resource and what are their test results in control points.

In the evaluation process, they are expected to be engaged students and lecturers from Faculty of Mathematics and Informatics at Sofia University.

6. Conclusions

Adaptive e-learning platforms tend to open one of the most promising research areas in next several years. In this paper, there was introduced an approach for self adaptive hypermedia applications using triangular conceptual model. The main benefit of the proposed model is in assuring strong independence of any of the building models and, at the same time, in facilitating a flexible adaptation of content delivery. It can be supported by different system architectures not limiting application of various adaptation techniques, such as adaptive presentation, navigation support and content selection. In order to be able to describe polymorphic learner profiles, we define conceptual characters of given domain such as characteristics of the learning style, psychology characters, etc.

In the paper there was described an adaptive process for e-learning content delivery. This adaptive process was formalized through the use of predicates and relationship between them. There were presented formal adaptive rules used by the adaptive engine to ensure self adaptivity. This formalization facilitates creation of a clearer specification for software construction of the adaptive engine. Using this formal model, there can be made reachability analyses of particular pages for user with given profile.

One of the issues for future improvement is to do more precise formalization. The formal model can be evaluated and compared with others similar. It can be implemented and by using artificial intellect and neuron networks for its realization.

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