Emerging Models and e-Infrastructures for Teacher Education

K. Stefanov, R. Nikolov, P. Boytchev, E. Stefanova, A. Georgiev, I. Koychev, N. Nikolova, and A. Grigorov

***Abstract*— The paper presents a digital repository of metadata resources for teachers education, as well as a portal for the community of practices, build around the repository. Both the repository and the community are developed in the frame of the European project Share.TEC. Some approaches for endowing digital libraries with adaptability capabilities in order to scaffold and enhance end user experience are examined. The paper provides a general overview of techniques and methods commonly adopted for achieving adaptability. It also discusses how these can be implemented. Finally, it illustrates specific examples and guidelines drawn from the practical experience that the authors are currently gaining in the Share.TEC European project. In this context the adaptability is a key for managing and responding to considerable diversity in user requirements.**

***Index Terms*—Content management, Continuing education, Information retrieval, Social network services, Digital libraries**

I. Introduction

THERE is a need of an institutional change of schools and universities in order to adapt to the current requirements of the networked and knowledge society. The e-Learning phenomenon and the ICT driven global educational reform lead to the needs of implementing new pedagogy models. The Web 2.0 technologies and e-infrastructures have great impact on education and research in schools and universities. The teacher's professional qualification designed to meet the new challenges is considered as a key problem for a successful penetration of this phenomenon in the schools. It is emphasized on the importance of designing a life-long teacher training strategy adapted to the new achievements in the technology enhanced learning research and the new learning theories. Building social skills and competencies appropriate to work in a Web 2.0 based learning environment and other global social software is desirable to be included both in the school curricula and the corresponding Teacher Education (TE) curricula.

The global education movement gave rise of the Open Educational Resources, which demonstrate great potential to overcome demographic, economic, and geographic educational boundaries and to promote life-long learning and personalized learning. Another similar educational movement is the Open Archives Initiative [1], aiming to achieve open access as the worldwide electronic distribution of peer-reviewed literature and completely free and unrestricted access to it by all scientists, scholars, teachers, students and other curious minds. First declared in Budapest, and best known as Berlin Declaration, it gives rise of the new set of standards, which become the heart of the contemporary digital libraries. Building such digital libraries is among the main priorities of the European Commission (EC), UNESCO and other international organizations. A typical example of such libraries is Europeana [2].

In order to answer to these new challenges, the EC funded project Share.TEC [3] is aiming to build an advanced user-focused system that aggregates metadata describing TE-related digital resources located Europe-wide. The system aims to offer personalized, culturally-sensitive brokerage for the retrieval of relevant digital content and to help nurture a more Europe-wide perspective among those working in and with the TE community. The more specific objectives of the Share.TEC systems are the provision of an effective brokerage system for TE; providing semantic, linguistic, cultural and technical interoperability, and fostering knowledge sharing and reusability.

In the rest of this paper we provide details of the Share.TEC system implementation and explain how we achieve the planned objectives. Section II provides details on the structure of the Share.TEC digital repository, stressing on the new TE ontology and the new TE metadata models developed, and how they are used in the system. Section III explains the user interface, while in sections IV and V we present some advanced features like adaptability, multilingual and multi cultural support, and the Share.TEC recommender system. In the section VI we explain how the system was evaluated, and in section VII we present some related works. In the conclusion we discuss the main results and propose ideas for further improvement of the system.

Manuscript received June 17, 2011. This work was supported by the SISTER project funded by the European Commission in FP7-SP4 Capacities via agreement no. 205030.

K. S. Stefanov is with the Faculty of Math & Informatics, Sofia University "St. Kl. Ohridski", Sofia 1164, Bulgaria (phone: +359 2 8657111; fax: +359 2 8687422; e-mail: krasser@fmi.uni-sofia.bg).

R. V. Nikolov, was with Sofia University, Sofia 1164, Bulgaria. He is now with the SULSIT University, Sofia, Bulgaria (e-mail: nroumen@abv.bg).

All other authors are with the Faculty of Math & Informatics, Sofia University "St. Kl. Ohridski", Sofia 1164, Bulgaria, e-mails: {boytchev ; eliza ; atanas ; koychev ; nnikolova ; Alexander.Grigorov} @fmi.uni-sofia.bg.

II. SHARE.TEC MODEL AND ONTOLOGY

Share.TEC system [4] uses digital libraries to store knowledge resources from the TE domain. Digital libraries are organized collections of digital content made available to the public by cultural and scientific institutions (libraries, archives and museums) and publishers. They can consist of all kinds of "physical" material that has been digitalized (books, audiovisual or multimedia material, photographs, documents in archives, etc.) and material originally produced in digital format. Knowledge sharing is the main function of digital libraries.

Metadata are the key for providing the needed meaning to the original resources, making them more transparent, easy to find and use. They are additional data, which describe details about the original data. These details may include different characteristics, features, links and properties of the original content. In the past metadata were used mainly to catalogue the books in the traditional libraries. Now metadata are the key for searching, finding and using the right data.

By using metadata we move from digital libraries to specialized massive metadata repositories combined with additional semantic information (most commonly in the form of ontologies and taxonomies) - digital metadata repositories, which try to categorize and link all possible information resources in a given domain.

The heart of the Share.TEC system is the central repository [5], storing metadata about TE resources. All metadata stored in the repository follow the Common Metadata Model (CMM) metadata format ([6], [7]), which is based on the Learning Object Metadata (LOM) format [8]. The main extension concerns pedagogical characterization of digital content.

In the frame of the Share.TEC project a specific ontology, called TEO (Teacher Education Ontology) ([9], [10], [11]) was developed. The goal was to provide more robust, flexible and powerful way for classifying TE resources in the central Share.TEC repository. TEO [11] addresses the world of Teacher Education (TE) and especially TE digital resources and practices across Europe. The ontology has a multi-layered structure, with a common top level that can be instantiated at lower levels into concrete, language-specific ontologies. These gain specificity by being contextualized in particular national settings.TEO purposes are:

-- Pedagogical characterization of digital content
-- Representation of user profiles and competencies
-- Multilingual and multicultural foundation
-- Personalized interaction with adaptive applications
-- Support for recommending functions

TEO seeks to capture the areas considered crucial for describing, exchanging, sharing, and developing resources devoted specifically to TE. Its complex structure is organized in a set of ontology branches, which are dedicated to:

-- Digital content (educational resources and artefacts closely related to the concept of "learning object")
-- Competencies (both at subject-matter level and transversally - socio-affective, meta-cognitive, etc.)
-- Knowledge domain (a taxonomy of various subjects, disciplines and educational topics related to TE)
-- Context (various contexts of action within the domain of TE)
-- Actor (persons in the TE context and in the Share.TEC system)

III. SHARE.TEC SYSTEM ARCHITECTURE

The Share.TEC system [12] is based on the set of scenarios and use cases specified within the project. They had provided the basis for the main system requirements, which have guided the development of the overall Share.TEC system architecture and functionalities. The general architecture is depicted in Fig. 1, including the main system components as well as the protocols used for their communications.

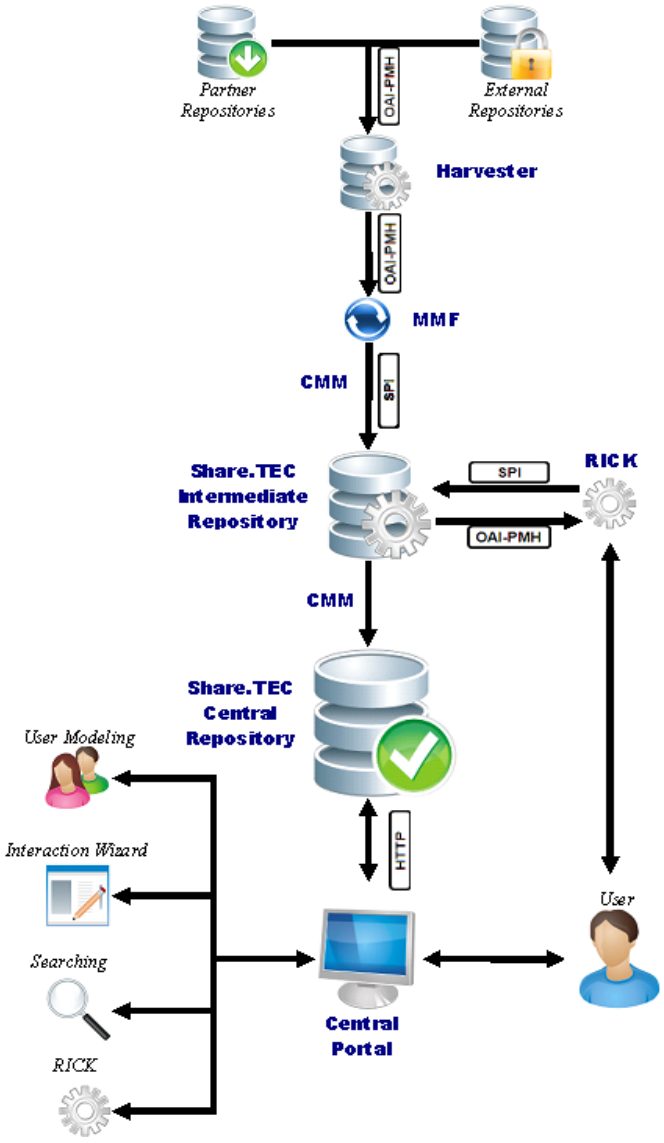

Fig. 1. Share.TEC architecture

The first main component in the Share.TEC system is the

Share.TEC *Repository*, also named *Central repository* or *Repository cache*.

This central repository stores metadata records describing resources from the TE domain. These metadata records are in the CMM format and are collected (or extracted) from compatible metadata found in various sources: partners' local metadata repositories, external repositories, or additional sources containing such metadata.

The central repository also contains a representation of the Teacher Education Ontology. The ontology was initially developed using the Protégé editor and was later imported into the central repository.

The second main system component is the *Portal*. This is where Share.TEC users communicate with system components and draw on its services. Here, the user interface plays a multi-fold role: representing the main system services and components to the user in a natural way; enabling him/her to express what they want from the system; formulating the right set of queries to the components and services involved; collecting the results from these components and services; representing results in a natural way.

The main set of services offered to the user is related to execution of different types of searches of varying complexity within the central repository.

The Share.TEC portal allows the automatic personalization of portal interface to match user's language, community role, and history. All queries can be performed in the project partner's native languages (Bulgarian, Dutch, English, Italian, Spanish, and Swedish).

The third main component from the system is the *Harvester*. The harvesting process is based the Open Archive Initiative – Protocol for Metadata Harvesting (OAI-PMH) protocol. It includes an OAI-PMH target (the point where a given digital repository is providing access to its metadata records through the OAI-PMH protocol), metadata validation service (program ensuring that all the harvested metadata records have the right data format), and the Harvester (program for importing metadata records taken from a number of digital repositories, into one central repository).

Other very important components for the system are the identified external digital repositories, containing metadata relevant for the TE domain, as well as the local repositories established at each project partner's site. These served as the initial databases from which the Share.TEC central repository was initially populated with metadata.

To support population of the central Share.TEC repository with CMM metadata records, a specific program called the MMF (Metadata Migration Facility) was also provided. The MMF's main function is to automatically translate harvested metadata records from existing formats (Dublin Core or LOM for example) to CMM and then to feed them to the central repository through the harvester.

In order to generate new CMM metadata records at partners' repositories, we provide a comprehensive support tool for the creation of metadata records called RICK (Resource Integration Companion Kit). There are in fact two such tools: Desktop RICK (aimed to support experienced users) and portal RICK (for novice users). The portal RICK can extract some of the metadata fields' values automatically (such as file type, owner, date, keywords, etc.) and it offers a web form to the user for filling all of the required and missing fields, as well as any other non-obligatory field. Both RICK tools store new metadata records in the system's intermediate repository.

IV. Portal Functionalities and User Interface

To make Share.TEC easier for users to navigate and use, the platform presents three main areas to explore and work in, namely **TAKE**, **USE** and **GIVE** (see Fig. 2).

Fig. 2. Share.TEC portal home page

These three concepts were adopted as central themes in the dissemination materials from the early stages of the project. Their integration as thematic gateways in the portal has received a favourable response in dissemination activities and has been viewed positively by target users in evaluation activities. The three areas can be summarized as follows:

-- **TAKE** is for locating resources. It includes simple and advanced search options, as well as different options for browsing resources.

-- **USE** has control panel type functions that give users an up-to-date view of recent activity on the platform and allow them to check and access their own artefacts and activity.

-- **GIVE** allows registered users to contribute to the community by uploading and describing their own resources, adding annotations and ratings.

Casual visitors have access to a limited range of basic functionalities. By contrast, registered/logged in users can take advantage of the full range of platform functionalities, including the portal's personalization and adaptability features (described in section V) and the possibility to enrich the platform and the community by adding their contribution. For users being logged in the platform logo changes from Share,TEC to MyShare.TEC, indicating that they have full rights accorded to registered/logged users and can expect personalization and adaptability during interaction.

From our needs analysis it was made explicit that the possibility to form groups of interest and to have specific

discussions inside these groups was the most important feature to have. We respond to this explicit user need with providing interest groups feature. The groups area provides functions for creating new groups; join an existing group; post a message to other group members; search for a group; invite a friend to a group via email; see who's online; suggested groups (users who joined this group also joined…); and automatic alert via RSS of new groups and messages.

V. ADAPTABILITY, RANKING AND RECOMMENDATION SERVICES

A. *Adaptability approach*

The Share.TEC system uses adaptability approaches [13] for the implementation of the following three adaptability features:

-- Adaptation of the user interface (based on the explicit user preferences given in the user profile).

-- Adaptation of the presentation of the search results shown to the user (based on explicit user preferences and on the implicit preferences calculated by the system on the basis of user behavior and available statistical data).

-- Specific recommendations to the user about resources and social interactions (based on the explicit user preferences and on the implicit preferences calculated by the system on the basis of user behavior and available statistical data).

The adaptive behavior of the Share.TEC system is mainly (although not exclusively) aimed at identifying those digital resources that better suit the users' needs, without asking them to enumerate the requirements in detail. Whenever possible, users are spared the disturbance of explicitly expressing these needs as query parameters, and the values are inferred from the user model.

B. *Interface customization*

User interface customization is a kind of adaptability which is explicitly controlled by the user and is stored in the user profile.

The system supports several ways to change the interface language, manually by using the field "Language", automatically depending on the user's profile and automatically depending on the default browser language, unless otherwise specified. Manual interface language change is temporary. Automatic setting of the interface language according to the user's profile is persistent. A registered user can specify the preferred working language during registration, and can modify this choice by editing the personal profile settings. For users who are not logged in or who have not specified their preferred language in their profile, the interface language is automatically set to English language.

The adaptability of user view to the information provided by the system is done by explicit preferences. The system has options for hiding and displaying different sections of additional information on the user's front page according to her/his personal preference. The user can choose which sections will be displayed on the front page such as – latest news from Share.TEC, list with the last added resources of its Area of interest, list with the last added annotations to resources of its Areas of interest, list with new registered users with the same Area of interest, notifications for new messages from other registered users and list with last visited from the user resources. All these elements can be selected or deselected by the user and become visible or invisible on her/his front page, depending on the personal preferences.

C. *Searching and filtering*

The advanced query function provides users with a form to specify parameter values for the CMM metadata elements: they are used by the query engine to select those metadata records that exactly match the required values.

This adaptability feature identifies what metadata fields are of interest to the users and these elements are shown in the query result list together with the name of the resource. For example, some users may prefer to know at a glance the content provider; others may prefer to know the authors' names. The result list can therefore be reordered according not only to the relevance of resources, but also to other descriptors, such as title, ratings, publication date, author's name, etc.

When examining the details of a given resource record, users can ask the system to find similar resources (i.e. querying by example) that share the same value for a specific metadata element, such as the same author(s), or the same knowledge area, etc. This is possible by choosing the option "YOU MAY ALSO LIKE TO SEE".

D. *Recommender system*

Share.TEC recommender system provides several main functions in order to help the user locate the most appropriate TE resource according to the user profile and history of activities [14]. For example, you may see some recommendations in the *Use page* under the *Recommended for you* label – see Fig. 3.

Fig.3. Resources recommended by Share.TEC

VI. MULTI LINGUAL AND MULTICULTURAL SUPPORT

A. *Multilingual approach*

Multilingual support, as referred to a software system, is a characteristic indicating that the system may provide its services in more than one human language. Additionally, such a system may accept queries and other requests by the user in various languages. Not every aspect of a system needs to be multilingual. For example, internal administration tools are not supposed to be used by ordinary users and they are not required to support multiple languages.

The Share.TEC system and portal have been designed to be multilingual from the very beginning. The Share.TEC components that support multiple languages are the metadata, the user interface, the help documentation and the user guides. The actual TE digital content, however, is not translated, because this objective is beyond the scope of the project and because Share.TEC does not possess the content, but only the description of the content.

Following the general concept of multilingual support, Share.TEC provides it in both directions of human-computer interaction:

-- The software can present information to the user in her/his preferred language.

-- The user can use her/his native language describing requests and inquiries sent to the system.

B. *Data multilingual support*

To provide multilingual support, a system should support internal representation of various data in multiple languages. The data in Share.TEC can be clustered into 4 levels (see Fig. 4). Each level of this multilingual support is consistent and transparent.

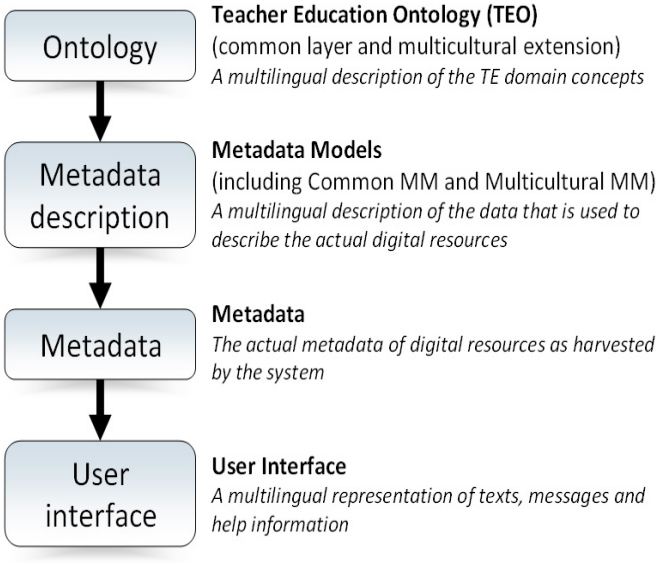

Fig. 4. The four levels of data in Share.TEC

The ontology as a data layer refers to both the common layer and the multicultural extension of TEO. In the common layer, concept names are expressed in English merely as expediency so as to facilitate readability.

The ontology in Share.TEC is multilingual by design. A concept is represented by a node, which contains its expression in various languages. The translation of TEO nodes was done offline in an early stage of the project.

Fig. 5 shows the logical structure of Medicine, a node that is part of the Knowledge Area concept. The node represents a language-neutral concept; it contains its lexical representation in three different languages and is connected with other nodes through parent-child relations. This exemplifies the simplest level of cultural extension, a one-to-one correspondence between a common-layer term and an equivalent term expressed in a partner language, i.e. translation. This structure is sufficient to support conceptualization, hierarchies, multilinguality and ontology stability.

.

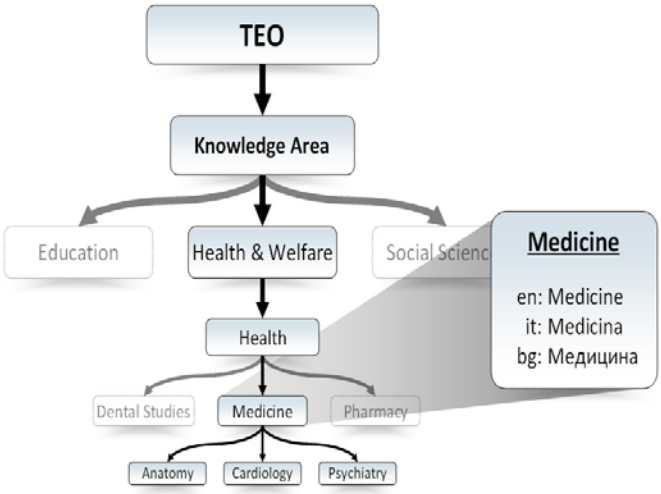

Fig. 5. Multilingual representation of the TEO node for the concept Medicine

The metadata description defines what technical and pedagogical attributes are associated to each digital document. These attributes are extracted from the ontology together with their translations. Thus the Common Metadata Model, which contains these metadata descriptions, is available in all supported languages. The collection of these language-specific CMMs is the Multicultural Metadata Model. The translation of the metadata description was done offline. Additional translations would be needed only if new languages are to be supported or new attributes are defined.

The actual metadata describing a digital resource exists in external digital repositories as a single language (most likely the official or the native language of the content or the metadata creator). When such metadata are harvested by Share.TEC, the elements are mapped onto a special repository-friendly representation of TEO. This allows the system to bind resource descriptions to the correct nodes of the ontology irrespective of the incoming language (at least within the range of TEO supported languages).

Whenever incoming metadata contain a concept expressed in a native language, the Share.TEC system scans TEO to find

the corresponding node. When such metadata is processed, it is replaced by references to conceptual nodes. This makes the internal representation of metadata language-independent and links various terms corresponding to the same concept.

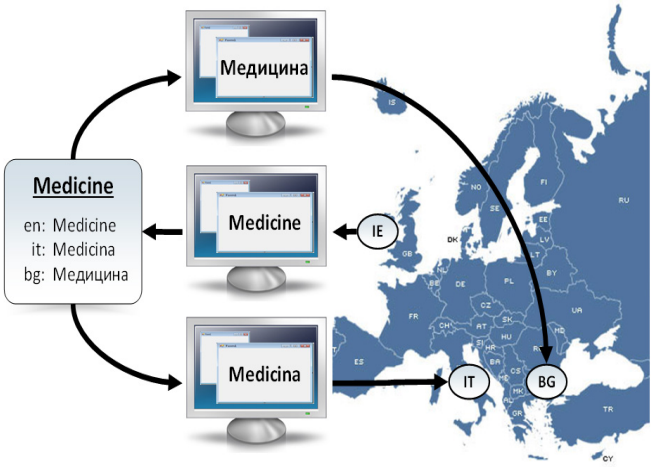

Fig. 6. Native languages and language-neutral conceptualization

Fig. 6 illustrates metadata translation to a language-independent concept. Consider a metadata record related to Medicine and harvested from an Irish repository. When this metadata record is processed by Share.TEC, it is bound to the concept node Medicine.

Share.TEC does a bi-directional correspondence. When metadata are shown to a user, they are translated to the preferred language. For example, metadata from an Irish source that contain the word Medicine are displayed to Italian or Bulgarian users as Medicina or Медицина. Both incoming and outgoing translations are done in real time using the repository-based instance of TEO.

C. *Portal multilingual approach*

The multilingual approach of the portal refers to four aspects: the digital resource metadata displayed by the portal, the metadata used as search criteria, the interface of the portal and its online help.

The metadata displayed in the portal are translated in real-time. The internal representation of metadata is language independent but its visualization is automatically translated into a language selected by the user (see Fig. 7).

Title	Fondamenti della Chimica - Il linguaggio della chimica	Fondamenti della Chimica - Il linguaggi della chimica
Resource location	http://cird.unive.it/dspace/handle/123456789/757	http://cird.unive.it/dspace/handle/123456789/757
Resource language	it	it
Keywords	medicine, reductionism, Dalton	medicina, riduzionismo, Dalton
Knowledge area	Teacher Training and Education Science Broad Programmes, Physical science, Chemistry	Formazione degli Insegnanti e Scienze della formazione, Scienze fisiche, Chimica
Learning Skills	Explain, Illustrate	Spiegare, Illustrare
Resource Type	Resource For Learners	Risorsa per studenti
Learning strategy	Resource-based learning	Apprendimento basato sulla fruizione risorse

Fig. 7. Metadata translated in English and Italian

When users query the Share.TEC repository, they either use free-text search or select for the search criteria related to the metadata elements. In the latter case the criteria are also automatically translated to the corresponding language-independent nodes in the repository's TEO. This provides the possibility to search in one language and to find relevant resources described in another language. TEO's role in the portal is for on-the-fly translation of metadata. It is not used for translation of page descriptions, button captions, form labels or on-line help. These texts are included in the Drupal part of the portal.

A special function of the portal allows users with sufficient privileges to work on their respective language version of the graphic interface. They can examine the level of translation, i.e. how many texts are translated, and provide some or all missing translations.

D. *Multicultural approach*

We enhance the TEO's multicultural features [11] by performing two steps.

The first step is to adjust the granularity of concepts. If there is a concept that is not atomic in all cultures, then this concept must be split. This step requires examination of all nodes in the ontology from representatives from all cultures.

The second step is to remove all translations of concepts that do not exist in a given culture. This insures that nodes are mapped correctly during multicultural searching. Removing unrelated translations is essential for multicultural support, and will not affect the user experience; users would still be able to see the description of the concept in any of the languages, because only concept names are liable for removal, while descriptions are kept intact.

A multicultural TEO unites all culturally dependent TEOs. It allows the run-time "extraction" of individual cultural-dependent TEOs. It is possible to treat local TEOs as projections of the global TEO onto the specific cultural domain, as in Fig. 8.

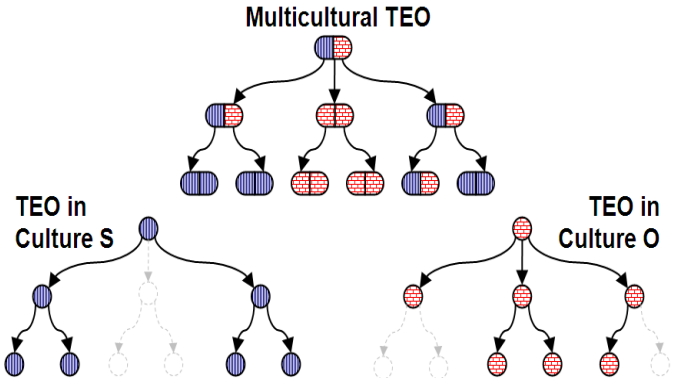

Fig. 8. Local ontologies as projections of the global multicultural ontology

One of the possible implications of this approach is the existence of discrepancies not only in the end nodes of the ontology, but also in nodes higher up in the hierarchy. It may happen that a whole sub-branch of a given taxonomy is missing from some culture. Fortunately, this is not a problem, because this branch should not contain translations of its nodes in this culture.

VII. SHARE.TEC SYSTEM EVALUATION

In order to evaluate the Share.TEC system, the evaluation and validation plan was developed [15], including three main validation activities: system performance validation, metadata validation and system usability validation. The system performance validation plan includes reliability and availability measuring. The metadata validation includes the definition of metadata quality and measuring how existing metadata records can be evaluated again the specified quality measures. The system usability validation includes Think Aloud Protocol (TAP) [16] evaluations in order to measure how the system is perceived by the end users in relation with the planned scenarios of system usage.

The system was evaluated three times: after the development of the first system prototype (end of the first project year), after the development of the pilot version (end of the second project year) and after the implementation of the final system (end of the third project year). All the evaluation sessions results were used for the improvement of the system. Here we will present the results of the third evaluation session.

According to *the availability*, the system was tested for one month period and was reported to have 99,5% availability measure. According to *the high throughput* and *short response time*, the system was measured using Apache JMeter tool, and the results show stable performance and no system performance degrades.

Concerning to *the metadata quality*, five levels were defined: incomplete, low quality, bronze quality, silver quality and gold quality [7]. The last tests report the higher levels of silver and gold quality, which shows that the metadata are really useful and contain the information needed by the users.

Concerning *the usability evaluation*, the Share.TEC system was evaluated by users from 7 different countries - a little more than 300 participants from the TE domain.

TAP is a method to gather a verbal report during usability testing [16]. A TAP participant is given an assignment and is asked to voice whatever they are looking at, thinking, doing and feeling. As expressing your thoughts while executing a task does not feel natural, participants execute the tasks in pairs. Having to discuss with each other what they are doing will facilitate the verbal exercise. An objective observer makes notes of everything the users say or do without trying to interpret their actions. In addition, all actions and speech are captured using recording tools, so that these actions can be replayed later.

> -- *Very friendly interface! It is easy! I feel comfortable in the portal!*
>
> -- *Oh, it seems it always shorter the path to concrete educational resources!*

These and similar expressions accompanied by quick orientation and exploration of the portal give us enough confidence that it is really useful for them.

All participants in the evaluation were given a few assignments that they had to carry out in teams of two people. They were asked to discuss their actions while they carry out the assignments. We asked the participants to reflect aloud on what they expect to happen when they click on a link or button.

After the tasks, a structured interview with the participants where we asked them to elaborate on the features they would prefer. For this purpose a few questions were prepared that took into account the status of the system to be tested and the objectives of the project.

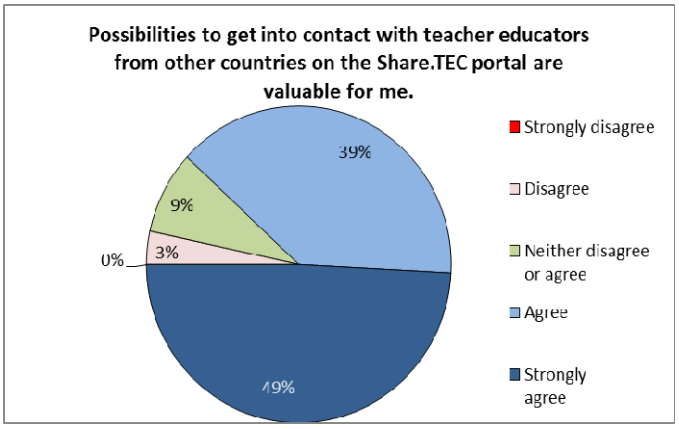

Fig. 9. Encouraging results of the usability evaluation

The results from the usability evaluation show enormous improvement since the first two releases of the system. Improvements that have been performed thanks to the feedback collected during the local testing and thanks to the interviews with experts on the field. Analyzing the testing and validation results, we can conclude that the Share.TEC portal provides appropriate learning and social environment for sharing not only digital resources for teachers' education, but also knowledge and experience for self development and

European teacher education community building (Fig. 9). The successful validation of the Share.TEC portal came as a result of the hard work and joint efforts of researchers, developers, and users. The authors share the opinion, that this is the only way to apply innovations in education in practice.

VIII. RELATED WORKS

There are many research and implementations related to the use of digital libraries in education. However, the combination of using ontologies and metadata, combined with advanced adaptability features, recommender systems and multicultural support for educational digital libraries is a rather new approach, with too few successful implementations. We can mention one of the first such attempts – the MACE project [17]. The goal of this project is to develop a digital repository in the field of architecture combining the use of metadata, ontology, competence taxonomy and social interactions. The use of non standard tools makes the results from this project difficult to reuse.

The similar approach is taken in the OpenScout [18] project, aiming to foster the knowledge and tools sharing in the domain of the management education. They want to combine the use of competence taxonomy and metadata profiles for resource indexing, but their more advance goal is related to exchange and share different software tools (tool library) as a men for teaching and usage of teaching resources. At this stage it is difficult to judge the success of this project, as the system prototype is at the very early stage of development.

Another important research is related to the so-called Enhanced Content Models [19]. They are built as an extension to the Fedora content models [20] and provide the way to implement and use ontology in a digital library built on top of Fedora Commons system [21].

Similar research for using recommender systems in digital libraries was performed in several research project funded by the German Research Foundation [22]. However, the lack of ontology or other knowledge representation scheme limited the use of the systems.

IX. CONCLUSION

The main result of the Share.TEC project is the design and implementation of the Share.TEC portal. In this paper we presented the key and innovative solutions adopted in the Share.TEC system, including: portal functionalities and user interface, multilingual and multicultural approaches, semantic layer (ontology and application profile), adaptability features and recommender system, portal architecture and the user-oriented interactive social services.

We presented the evaluation approach and the results from the validation activities in relation with the Share.TEC system. We also provided some similar research projects to compare with our research results.

The work on the Share.TEC system will continue after the end of the project. We already consider implementing a list of possible extensions and improvements to the Share.TEC system, including handling secure payments, making a complete track of user actions, adding more user-interface languages, improving the graphical browsing of resources, implement user notifications for deleted/changed resources, etc.

REFERENCES

[1] Open Archives Initiative, Available: http://www.openarchives.org.
[2] Europeana: European Cultural Digital Library, Available: http://www.europeana.eu/.
[3] Share.TEC project Web site, Available: http://www.share-tec.eu/.
[4] Share.TEC system, Available: http://portal.share-tec.eu/.
[5] Stefanov, K., Boytchev, P., Grigorov, A., Georgiev, A., Petrov, M., Gachev, G., and Peltekov, M., "Share.TEC Repository System", In Proceedings of First International Conference on Software, Services & Semantic Technologies (S3T, 29-29 October 2009), Eds.: D. Dicheva, R. Nikolov and E. Stefanova, Sofia, Bulgaria, 2009, pp. 84-91, ISBN 978-954-9526-62-2
[6] Share.TEC Project deliverable D2.2 Common Metadata Model, Available: http://www.share-tec.eu/content/1/c6/04/41/02/D2_2_Common_Metadata_Model.pdf.
[7] D3.4 Metadata Repository Population, Available: http://www.share-tec.eu/content/1/c6/04/41/02/22_D3_4MetadataRepositoryPopulation.pdf.
[8] Learning Object Metadata (LOM) format, Available: http://ltsc.ieee.org/wg12/files/LOM_1484_12_1_v1_Final_Draft.pdf.
[9] Share.TEC Project deliverable D2.1 Teacher Education Ontology v.1, Available: http://www.share-tec.eu/content/1/c6/04/41/02/D2_1_TEO_v1.pdf.
[10] Share.TEC Project Deliverable D2.3 Ontology and Metadata Models, Available: http://www.share-tec.eu/content/1/c6/04/41/02/DEL2_3Finalreleaseversion.pdf.
[11] Boytchev, P.,Bocconi, S., Stefanov, K. An Ontological Approach for Multicultural Digital Repositories, Second International Conference S3T, September 11-12, 2010, Varna, Bulgaria , 2010, ISBN 978-954-9526-71-4.
[12] Stefanov, K., Boytchev, P., Grigorov, A., Georgiev, A., Petrov, M., Gachev, G., and Peltekov, M, "Share.TEC System Architecture", In Proceedings of First International Conference on Software, Services & Semantic Technologies (S3T, 29-29 October 2009), Eds.: D. Dicheva, R. Nikolov and E. Stefanova, Sofia, Bulgaria, 2009, pp. 92-99, ISBN 978-954-9526-62-2.
[13] Boytchev, A. Grigorov, J. Earp, K. Stefanov and A. Georgiev Adaptability Approaches in Digital Libraries, Second International Conference S3T, September 11-12, 2010, Varna, Bulgaria , 2010, ISBN 978-954-9526-71-4.
[14] P. Boytchev, A. Grigorov, L. Sarti, A. Georgiev, K. Stefanov and M. Chechev, Recommender systems and repository search: the Share.TEC proposal, Sofia University e-Learning Journal, 2010/3, ISSN 1314-0086.
[15] Share.TEC D1.7 Annual Report 2, Available: http://www.share-tec.eu/content/1/c6/04/41/02/D1_7Annual_report_2.pdf.
[16] Lewis, C. H. Using the "Thinking Aloud" Method In Cognitive Interface Design. Technical Report IBM RC-9265, 1982.
[17] The MACE Project, Available: http://www.mace-project.eu/.
[18] The OpenScout Project, Available: http://www.openscout.net/ .
[19] Enhanced Content Models For Fedora Commons 3.x, Available: http://sourceforge.net/apps/mediawiki/ecm/index.php?title=Main_Page.
[20] The Fedora Content Model Architecture (CMA), Available: http://fedora-commons.org/documentation/3.0b1/userdocs/digitalobjects/cmda.html.
[21] Fedora Commons Repository Software, Available: http://fedora-commons.org/.
[22] Michael Mönnich, Marcus Spiering, Adding Value to the Library Catalog by Implementing a Recommendation System, D-Lib Magazine, May/June 2008, Volume 14 Number 5/6, ISSN 1082-9873.