Knowledge Management and Sharing in E-Learning
Hierarchical System for Managing Learning Resources

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Abstract: Management and effective usage of learning resources is becoming increasingly difficult due to several reasons. Firstly, teachers do not usually have enough time and motivation to compile resources for specific learning course in the unified well-arranged way. Secondly, the internet provides almost limitless amount of information and attracts learners, who however do not have a necessary expertise to distinguish reliable and useful information to the particular topic. This problem is especially pronounced in fields of study, which are continuously evolving, such as medicine or software development, because the knowledge (and learning resources as well) needs to be regularly updated. In this paper we review the existing solutions and then propose a new system, which could deal with this continuous evolvement. Our solution is to create a flexible resource-rich hierarchical learning environment, which supports a collaborative building of learning resources for the specific knowledge domain. Presented knowledge management system is based on the shared hierarchy, user contribution and moderated improvement of learning resources. The ultimate goal of this system is, in addition to making teaching and studying easier and more effective, support of collaborative building of learning resources and enrichment of communities of teachers and students.

1 INTRODUCTION

Many fields of knowledge face serious information overload with an increasing amount of knowledge, accessible especially via the internet. This is mostly the issue of domains, which are under continuous progressive development, e.g. medicine or computer science. These fields of knowledge often require lifelong learning and frequent changes in working processes. Therefore it is also extremely difficult to maintain up-to-date information for learning courses, which are focused on such domains. These courses would benefit from collaborative efforts in building and updating their curriculum, learning materials and supplementary online resources.

The amounts of information accessible on the internet can be help but also serious obstacle for the active learner. Which search result should I choose? Which will deliver me up-to-date credible information? Considering contemporary strategy of search engines, generally the older websites are seen as more credible and placed on top in search results. This approach is not ideal for topics with progressive development, presented usually on newly created pages. Additional issue in such "self-procurement" of information by learner is that he usually has not the necessary insight, as to distinguish useful and reliable information according to the course requirements and his advancement in the particular subject. Suitable solution would be for the teacher to provide up-to-date relevant external resources as a supplementary material in addition to the main learning course.

This paper presents a proposal of web-based e-learning system, which aspires to manage learning resources for purposes of learning courses. One of the key points of our solution is the possibility of entry customization for students, as well as adding new entries and custom groups and thus creating personalized learning experience. The next strong point is the option for teachers to evaluate new custom entries, which they can consequently add to the shared hierarchy, accessible for other students as well. This continuous process can eventually lead to the collaborative building of learning resources and enrich communities of teachers and actively involved students.

Collaborative building of learning resources would also lead to an improvement of the course. This approach would also greatly benefit students,

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which are beginners in this field or not so active. These students would gain access to the maintained hierarchy of learning resources for making their studies easier and more effective.

2 RELATED WORK

2.1 E-Learning and Knowledge Management

Knowledge management includes the creation, archiving, and sharing of valued information, expertise, and insight within and across communities of people and organizations with similar interests and needs, the goal of which is to build competitive advantage (Rosenberg, 2006). E-learning is the use of information and computer technologies to create learning experiences (Horton, 2006).

Knowledge management and learning have many similar traits and we can observe almost synergistic relationships between these disciplines. Both disciplines deal with knowledge capture, sharing, application, knowledge generation, and both of them ultimately contribute to the building of the continuous learning culture (Liebowitz and Frank, 2010).

While knowledge management relies on a framework of sharing and transfer of knowledge, e-learning can be understood as the development of individuals' knowledge through a pedagogically designed learning process (Clark and Mayer, 2007). Nevertheless it was summarized that e-learning and knowledge management can function as complements and components critical to learning (Ungaretti and Tillberg-Webb, 2010).

2.2 Collaborative Learning and Knowledge Sharing

Development described in the previous section suggests that a solution for successful learning management should employ a structure for merging individual knowledge into organizational knowledge. Integrating individual learning with organizational learning was considered already in the framework for knowledge creation process (Nonaka and Takeuchi, 1995). The value proposition of knowledge management has shifted from local to centralized, decentralized, and finally sharing of knowledge among employees (Bonifacio, et al., 2008).

Collaboration in a learning environment can take place between teachers and students, or also within each group. It is known that one of the main sources of the knowledge creation process is the diversity of individuals' knowledge and experience (Nonaka and Takeuchi, 1995). At the same time, collaborative activity, as a dynamic form of support, results in improved collaborative learning outcomes (Karakostas and Demetriadis, 2011). Also Bernuy suggests joining knowledge management and intellectual capital into the collaborative model (Bernuy, 2011). It was researched that advancements in concepts of learning theories can be further incorporated into the management of organizational knowledge creation processes (Yoon et al., 2009).

Collaborative generation of content can be seen also in modern environments - widespread Web 2.0 concepts experience an exponential growth of both users and content, leading to potentially viral social networking, collaboration, communication and knowledge sharing (Govaerts et al., 2011). We can conclude, that the scope of learning and performance technology professionals' work has also over the past decades continuously expanded from an earlier focus on improvement of the individual learning towards enhancing learning and performance at system-wide levels, such as work groups, organizations or communities (McLean, 2006; Swanson, 2007). Another research suggests that individual, collaborative and organizational learning are deeply intertwined and mutually dependent in a work-integrated learning (Prilla et al., 2012).

In conclusion, knowledge management shifts from individual towards organizational, while in e-learning is a significant movement towards collaborative learning. Creating and updating learning resources should be then transformed into the collaborative activity, in which both teachers and active students can participate. As Majid et al. stated: Knowledge sharing is a key to effective learning (Majid et al., 2011).

3 MANAGEMENT OF LEARNING RESOURCES

3.1 Overload of Learning Content

As was already mentioned in the introduction, there is a vast amount of learning content available on the internet and learner can easily find online dozens, hundreds or even thousands of instructional texts,

tutorials and electronic text-books (Guerra et al., 2013). These resources are heterogeneous and can be organized in many different ways. E.g. by focusing on different parts of domain knowledge and covering the same parts with different levels of details, by using different terms for the same concepts (synonymy) and the same terms for different concepts (polysemy), by aggregating and structuring domain knowledge with different sets (or hierarchies) of chapters, sections, pages, etc. (Sosnovsky et al., 2012).

Previous section concluded that sharing and transfer of knowledge is the domain of knowledge management, while e-learning develops individuals´ knowledge through a pedagogically designed learning process (Clark and Mayer, 2007). However existing learning resources, especially in higher education and lifelong learning, are rarely precisely established, less so organized and unified in their form to create a fluent learning process. Continuous development in particular fields of study further complicates these efforts.

3.2 Need for a Flexible Knowledge Management in E-Learning

The idea of managing learning resources is far from new, yet the existing solutions do not offer flexibility for dealing with an evolving content. Additionally, neither of existing solutions is primarily focused on effective management of learning resources. Main purposes of these systems are summarized in [Table 1].

File management proves highly ineffective due to its limited usability, especially inability to treat links and references on the same level as stored materials and absence of any supportive structure or functionalities. Traditional content management systems can be used in e-learning similarly as Wikis or digital libraries - for presenting learning content, usually in unstructured textual form, with limited possibilities of filtering or sorting. These systems usually continuously accumulate content and make it available to users, who may face similar information overload as with the Google search. Knowledge management in progressively developing fields of study should be more about refinement of available resources, replacement of old ones with new, and maintaining high-quality knowledge base.

Bookmarking sites have their usage in management of url references, but as not all learning resources can be added in this form, their usage for our purpose is limited. Ontologies can be used for clarifying e.g. main categories, topics and other supportive structures for organizing learning content, but not for the content itself.

Learning management systems usually include management of learning resources, its usability varying from simple file-based storage to quite rich interfaces. However since their focus is primarily on the learning experience, along with assessment and coordination of the course, and the interface is crowded with amount of functionalities, knowledge management is hard to maintain. It also cannot be reused easily, since it is bound to the particular LMS implementation. Also individual implementations of LMS are usually bound to one school or organization, while efforts in maintaining such a database of learning resources should be put into a more open project.

Table 1: Primary focus (or main purpose) of tools and systems, presented in the previous section.

Tool / System	Primary focus / purpose
File management	storing files in folders
Content m. systems	administration of websites
Learning m. systems	learning platform for managing learning courses
Wikis	collaborative tool for creating learning content
Bookmarking sites	management of links
Digital libraries	creating or accumulating learning content
Ontologies	modelling knowledge domains

4 NEW SYSTEM PROPOSAL

4.1 Key Points of the Solution

The authors propose a new system with primary focus on managing learning resources for continuously developing fields of knowledge, which could prove very useful especially for lifelong learning, but also in regular learning courses. Key points of this solution are discussed in the following subsections, based on previous review of the existing solutions.

4.1.1 Flexibility and Adaptation

In order to manage an evolving knowledge, the management system has to be flexible as well. The basic requirement is an adaptable basic structure as well as supporting structures, so the system could react to changes in the chosen domain. For this reason, we cannot use ready-made solutions like

Wiki, neither core or customized CMSs such as Joomla. We can either develop our own application from scratch or use a content management framework to develop tailored content management system. Learning resources are usually not homogenous, and once applied content segmentation cannot in long-run deal with the new development or requirements in a progressive discipline. With means to edit architecture as well as content, we get a truly flexible and scalable system.

4.1.2 Structured Content

There is a continuous effort of converting content into a structured form, e.g. databases and template systems. Wikipedia (available at http://wikipedia.org), one of the most popular collaborative projects, is also trying to transfer unstructured textual data into structured data, in the shape of the project DBpedia (available at http://wiki.dbpedia.org/). Not all data and especially knowledge can be however structuralized. In that situation, we need metadata, for further specifying entries in the system.

Metadata (data about data) have a fundamental role in organizing and managing digital resources, especially when there is a great quantity of information that must be indexed to facilitate search and retrieval of information (Pani et al., 2012). Hierarchy of the proposed system provides useful metadata in its core structure. This is especially placement in the hierarchy (category, related entries), which is not bound to the particular entry but reflects actual state of the whole system, and secondary structures (e.g. topic). Then content segmentation can be used for metadata (title, headlines) and finally metadata such as annotation and keywords, which are not part of the content and are added subsequently.

4.1.3 Organization Structures

Key roles of any knowledge management system are creating, accumulating, organizing and disseminating information (Rosenberg, 2006). Accessing knowledge (in the form of individual entries) in the new system should be enabled by several structures for organization.

There are generally five ways to organize information:

- category (by similarity or relatedness)
- time (by chronological sequence)
- location (by geographical or spatial reference)
- alphabet (by alphabetical sequence)
- continuum (by magnitude)

(Lidwell et al., 2010).

Furthermore, we have for our disposal supporting functionalities such as sorting, filtering and searching. Intersection of these constructs and functionalities are indicated in [Table 2]. Primary hierarchy should arise from constructs with filter and search mechanism. In this general case, that would be entry type, role or topic. Entry type refers to the form of the entry (e.g. url reference, pdf file, image, ...). Role refers to the role of the learning resource in relation to the whole field of study (e.g. main idea, tutorial, supportive material, examples, demonstration,...). Their suitability should be considered for the particular knowledge domain.

Table 2: Basic constructs for organizing information and their suggested application in the system.

Construct	Property	Mechanism
Category	topic, entry type, role	filter, search
Time	created, added, edited	filter, sort
Location	field of study	filter
Alphabet	title	sort, search
Continuum	level / priority, rating	filter, sort

4.1.4 Continuous Refinement

Learning resources are typically being accumulated in various management systems and grow in number. This tendency could be also caused because electronic space has no limits such as physical or time space. Continuously developing fields of knowledge, more than other fields, suffer from information overload, overlapping of individual materials and references and also cluttering by obsolete knowledge. The learning resources for these domains need to be maintained and refined. Old resources should be replaced by new, if it is desirable in such field, and better resources should prevail over worse resources. The result should be regularly updated high-quality knowledge base.

4.1.5 Collaborative Aspect

Importance of collaboration in creating knowledge was mentioned several times in previous sections. Collaborative building of learning resources is therefore suggested in this paper as a viable solution of knowledge management in this area. Collaborative aspect in the proposed system is ensured by cooperation of several users in the role of the teacher, as well as contributions from users in the role of the learner. Entries updated (added,

edited or erased) by learners should be however not incorporated into the central (shared) knowledge base, but only to their customized copy of the database (in fact only copy of the respective portion of the knowledge base, for performance optimalization). From here, teacher could accept new entries or changes, if he agrees with the proposal. Thus would be managed moderated improvement of the central knowledge base.

4.1.6 Customization and Personalization

Customization refers to the structure or style of the web page, while user personalization usually refers to the content itself (Bouras and Poulopoulos, 2012). While the system should certainly have some means for customization, e.g. in composition of application frames, theme and colors, or customized homepage, more interesting for us is the personalization. Students frequently create their own repository of learning materials, either as a local copy of course materials or they are accumulating their own resources or the combination of both.

Our solution would be to offer them personalization of the knowledge base, in particular the following possibilities:

- updating existing attributes of existing entries
- removing entries (with the option of restoring)
- creating, updating and removing user entries
- adding new user-specific attributes to both existing entries and user entries, e.g. personal rating, notes, progress etc.
- creating, updating and removing user groups, in which both existing entries and user entries can be stored, without removing them from the original place in the hierarchy

4.1.7 Reusability of the Knowledge Base

An ambitious version of this project could manage a knowledge base of the particular field of study as an open-source worldwide project. This base would be reusable in popular LMSs and users (teachers) could import only that part, which would be interesting for their learning course or personal use in lifelong learning. This would require live connection for keeping up-to-date learning resources. Our solution would then serve more as a knowledge base and management than e-learning, which would be provided by LMS. In this case however, the collaborative aspect would be lost for the end users of LMS, replaced by its own politics. It would nevertheless be available in the central project, which the exported parts would synchronize with.

4.2 Selected Issues to Consider in Implementation

4.2.1 Users and the Key Activities

Proposed system for managing learning resources will support two primary types of users - the teacher and the learner. Both roles of teacher and learner would have access to the central knowledge base of learning resources.

Teacher has rights to create, change or delete entries and categories. Students have not all of these rights, in order to keep high-quality of entries, but they can view these entries, customize them and create their own entries, which they can place into their own categories. Learners have full rights to these user entries and groups.

In order to transform personalized knowledge management into a collaborative activity, teacher has access (and simplified interface) to personalized and user entries of learners, which he can evaluate, approve and add to the central database. He could also reject the entry, but this action should not delete entry from user´s account. There would be only an option for sending a message to the learner about inadvisability of his resource.

The basic model would implement one teacher and many students. The advanced model would support more teachers, which could collaborate together on the central shared knowledge base. There is also a possibility for differentiated categories of learners, which could be then engaged accordingly in collaborative groups.

4.2.2 The Knowledge Base

The flexibility of the architecture should manifest during both creating the basic structure and modifying it. Flexibility in creating the structure consists of adapting individual attributes of entries (in other words: data, which we want to store for each entry). There are some generally usable attributes such as title, topic or rating, but every field of study can have also some specific attributes. These attributes are then used for knowledge retrieval, in a form of filtering, sorting or searching, as organization structures (see section 4.1.3). This flexibility consequently lies also in adapting the usage of these structures throughout the system (primary structure as the main hierarchy and others as supportive structures). Flexibility in modifying the structure includes change of the attributes and change of their use in the system.

In a conventional scenario, the main hierarchy would refer to organization by categories and subcategories, usually made by theme or topic. The task of defining these categories would naturally fall to the teacher role. His task would be also an opening compilation, which is the initial submission of the existing learning resources.

Following are proposed types of entries for general use in learning:

- Documents - Word, PDF, HTML
- Presentations - Powerpoint, Flash, HTML
- Data - Excel tables, graphs, schematics
- Multimedia - images, audio, video
- Interactive content - models, animations
- References - domain URL, single page URL

There could be also support for various file extensions of the software, which is used in the particular field of study. These new types of entries would benefit from the flexible structure and could have special attributes. The important issue is to ensure the equal position of various types in searching, filtering etc.

4.2.3 Technical Solution

Teachers and students would access the system through the web user interface. Web application is ideal for our purposes - it ensures online access, immediate changes, synchronization and no need to install any software. There would be one central shared knowledge base, which would be accessible to every user of the system, and personalized users´ accounts for individual learners.

With regard to the required flexibility of the system, we could either create a new system or use a content management framework, which is far less demanding solution. Such versatile and scalable framework is e.g. an open source CMS Processwire with custom fields (Cramer, 2014).

4.2.4 Basic Information Architecture

Central shared hierarchy consists of categories, entries and their sub-equivalents. Attributes of learning resources for general use were proposed as followed: title (name), description, related topics, notes, url (if it is an online source), attachment (if it is a material), priority of source and its rating. Role of the learner can personalize his learning resources by adding user groups or entries. Personalization in this proposal is available by adding user´s own notes, priority, rating and also progress (in learning this resource). This elevates the whole system into a personalized knowledge base and learning experience, which could supposedly attract students more than just static read-only database. For proper functioning would be also necessary operational attributes as ids, dates or indicators of status for various supportive processes (e.g. processes regarding approving user entries).

5 CONCLUSIONS

In this paper were reviewed existing solutions for management of knowledge and learning resources. These solutions were considered to be insufficient for the fields of knowledge with continuous development and lifelong learning. As a viable solution was proposed a new system. With this system, learning resources can be at the same time centrally managed and collaboratively continuously improved by moderated contributions, leaving room for personalization as well. Concept of this system was presented as a set of requirements and key points, proposal of user roles and key activities, basic information architecture and selected implementation issues.

Future research will extend and refine the original idea and provide answers for specific implementation issues as well as integration of this system into the learning course design. Information architecture would be also reconsidered according to further development of requirements and processes in the system. The next vital objective would be defining organization structures for managing learning resources in the selected field of study, followed by creation of opening compilation. The case study could be then conducted on a group of students in order to validate this solution and suggest improvements.

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