INTEGRATING PERSONALIZATION IN E-LEARNING

COMMUNITIES

Maria Rigou, MSc
Research Academic Computer Technology Institute
61 Riga Feraion Str. 26110 Patras, Greece
E-mail: rigou@cti.gr

Spiros Sirmakessis, Assis. Prof.
Research Academic Computer Technology Institute
61 Riga Feraion Str. 26110 Patras, Greece
and
Hellenic Open University
K. Palama 84, 26442 Patras, Greece
Tel: (+302610) 960-420
E-mail: syrma@cti.gr

Athanasios Tsakalidis, Prof.
Department of Computer Engineering and Informatics
University of Patras, 26500 Patras, Greece
Tel: (+302610) 996-936
E-mail: tsak@cti.gr

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ABSTRACT
Web-based learning environments give e-learning new potential by enabling personalized, interactive, just-in-time, current and user-centric learning tools. In this work we present the architecture, design and implementation of a web-based learning environment that can be used to build and support online learning communities. New material can be uploaded and positioned through a simple web interface that also allows for account management, definition of topic associations (that lead to the production of recommendations for further reading) and a set of additional explicit and implicit adaptations produced dynamically for personalizing the overall learning experience. Online learning communities may greatly benefit from incorporating adaptive features which take advantage of the knowledge and experiences of community members and use it to better serve each individual depending on personal preferences, goals and needs, as well as the history of community activity.

KEYWORDS: personalization, e-learning, online communities, web applications, web mining, recommendations.

INTRODUCTION
The traditional educational model assumes that people willing to learn are obliged to visit a training center which may or may not be close to them. This model takes for granted that knowledge is located at a certain place and people have to reach for it. Nowadays, this scenario is not obligatory, since it is feasible to have knowledge available to all, by placing it on the web. The last years, the rapid development of the Internet has allowed for a significant
growth in the e-learning sector, and there are grounds for even bigger growth and wider acceptance. According to the Digest of Education Statistics (1999), “education expenditures account for over 7% of the GPD, making it second in size behind the healthcare industry”.

Learning on the Internet has played a major role towards this direction, as it features as an ideal way of reducing teaching expenses dramatically, while raising the time and location constraints imposed by traditional teaching scenarios.

e-Learning systems of today, apart from ensuring high quality content, correct and efficient structuring, as well as support for the tasks of all user profiles participating in the learning process, have drastically evolved and incorporated methods and techniques from other domains and application areas, such as data mining, web content, structure and usage mining (Cooley et al, 1999; Spilioupoulou, 1999), user modeling and profiling, artificial intelligence, agent technologies, and knowledge discovery. More recently, techniques that were initially deployed for the e-commerce domain, in support of activities such as personalized marketing, cross-selling, up-selling, and generation of product recommendations (using clustering, similarity indexing, association rules mining, collaborative or content-based filtering as the underlying technology) are transferred and applied to the e-learning domain. These techniques aim to tailor and deliver to users an instance (or a “view”) of the e-learning environment that best suits individual needs, preferences and objectives, or the view that best implements the learning strategy that has been decided by the tutor for a specific student or cluster of students. To this end, researchers develop systems able to adapt themselves by observing, recording and analyzing user activity (adaptive systems) (Brusilovsky et al, 1998), or systems that can be explicitly “tuned” by users (adaptable or customizable systems) (Manber et al, 2000).

The issue of upgrading the online learning experience for all participating actors brings up one of the basic ingredients of successful learning: sharing through communication, which
develops the feeling of belonging to a group of like-minded people that forms a community. Particularly in the case of online learning that is by nature remote and impersonal, the notion of setting up a community is of vital importance on the path leading to successful learning. Communities share common problems, needs and goals and can promote solutions and progress if one gains insight into their “accumulated” knowledge. In our context, this knowledge exists in the form of navigation paths recorded in server logs. Different learning communities may regard themselves differently, but for the purposes of an integrated and common definition four core functions of learning in a community environment can be distilled as follows:

- **To develop skills**: In this context, the skills to be developed range from basic literacy and numeracy to those required to adjust to new employment opportunities (e.g. IT skills) or those needed to better cope with life (e.g. environmental knowledge; fitness). In addition, a learning community can assist in building community capacity to find solutions to problems and challenges.

- **To grow business**: An increased skills base and community capacity can contribute to expanding commercial opportunities (e.g. greater diversity of service providers in the knowledge economy, a greater capacity to win tenders for community services) and to more efficient business alliances.

- **To foster collaboration**: Many of the achievements of a learning community are intangible ones, embedded in the process of developing and maintaining the entity. They are also manifested in better sharing of resources (e.g. the use of school infrastructure after hours; joint advertising of adult learning classes; better use of libraries and community centers). Collaboration can also be fostered within government, so that solutions offered to communities match the local needs rather than funding structures across government and between the three tiers of government.
• To strengthen community: Learning is the key to sustainability. For example, good outcomes in health and environmental management are achieved when a person understands a problem and is capable of learning to change their behavior in order to implement the solution. Moreover, willing and being able to learn are great antidotes to boredom, poor self-esteem and despair. Healthier, cleaner and happier communities are stronger ones.

Numerous communities are available world wide, such as the Ballarat a Learning City (http://www.ballaratlearningcity.com.au/), Buloke Learning Towns (http://www.bulokelearningtowns.net/), Canberra - Learning Territory (http://www.lcc.edu.au/lcc/page68.html), Centre for Lifelong Learning and Development (http://www.premcab.sa.gov.au/lifelong-learning/), Glasgow The Learning City (http://www.glasgow-learning.net/), Learning City Bendigo (http://www.learningcitybendigo.com/index.shtml), etc. This work presents LearnCom, a web environment for setting up and supporting the operation of online learning communities – an early version of the system has been introduced in (Christopoulou et al., 2002). LearnCom’s distinctiveness lies at the fact that it incorporates personalization mechanisms for coping with different user profiles, preferences, goals and needs. More specifically, the implemented pilot system extracts community knowledge and experience from the recorded personal learning history of the community students and combines it with the domain expertise and didactic experience of the community tutors, as well as the activity level of each student resulting in the construction and delivery of a personalized version of the system to each community member. It is our claim that this approach to web based learning promotes the community concept, and at the same time expands, it by fostering and serving the diversity of individuals.
The remaining of this paper is organized as follows: section 2 describes the modules of system architecture, while section 3 refers to supported system and user services. Section 4 provides a closer look to the implemented personalization mechanisms and section 5 refers to the feedback we received from using LearnCom in real-life conditions. The last section concludes with our thoughts on future system expansions.

ARCHITECTURE

The prime objective of the system is creation, operation and support of online learning communities. The notion of an electronic learning community suggests a virtual place that hosting a variety of learning modules that can be reached by people from different and remote physical locations, emphasizing the communication among them. Thus LearnCom should not be merely perceived as a distance learning application, in the narrow sense that people can remotely access information. The focus is rather placed on setting up virtual communities of learners and tutors that are provided with the necessary IT tools for communicating with each other.

The system assumes three discrete profiles: students, tutors and administrators, with the first two accessing all available training content and structure and the last one assuring smooth and consistent system operation. Students are the main target group, as they are to use the system for learning and communicating. Tutors determine the contents and exact positioning of the modules they create and upload in the system and are also assumed to provide feedback and guidance to students by suggesting modules to revise or to advance their learning. Administrators are responsible for system configuration and maintenance, as well as for managing user accounts.

The social requirement of a learning community is two-fold: synchronous and asynchronous, with each mode contributing to the implementation of the corresponding communication and collaboration scenarios. In order to facilitate asynchronous communication, the system
provides the means for message exchange through the “Forums”, the “Questions & Answers” and the “Submit a Question” facilities. On the other hand, the incorporated “Chat” component provides for synchronous communication, which is considered equally (if not more) essential, as it fosters a sense of directness when interacting within the community boundaries.

System architecture (depicted in Figure 1) is composed of three distinct layers. The core layer provides basic system functionalities (such as data storage), the intermediate layer utilizes the functionalities implemented in the core layer in order to support the services appearing at the interaction layer, and the interaction layer forms and delivers the web interface accessible to all community members by a web browser.

**Figure 1: System Architecture**

**Core layer**

The core layer facilitates the file system, the database system, a web server and a chat server.

The file system is used to store the primary learning content in the form of learning module
files. Learning modules are divided into lessons and topics, which are stored as separate files, in order to achieve better download speeds. In addition to learning content, the file system also maintains help and glossary files. The database system is used to store a variety of data. It keeps personal data on the user profile and user authentication. Tutor and student records are also stored there. Moreover, it maintains the required information for describing the schema of the learning modules and holds data relevant to both the design and the content of the Forum, the Questions & Answers and the Bulletin Board services. The chat server synchronizes real time communication by managing message exchange between community members and assuring that messages are routed to the appropriate recipients. The web server accepts user requests and serves back the corresponding data. The returned data are not static web pages, but dynamic content constructed “on the fly” combining information maintained in both the file and the database system and which regards –in the case the user is a student– the personal profile and recorded history, as well as the pre-decided teaching logic.

**Intermediate layer**

The intermediate layer interconnects the core layer components and provides all necessary information to the interface layer. ASP scripts are deployed to retrieve data from the database and the file system and create the HTML pages that are served to the user; a process that is executed on the web server. JavaScript code is embedded in the HTML pages for dual functionality; one part is used to provide assistance to the user when navigating the system and filling-out forms, and the other part to ensure a user-friendlier interaction.

**Interaction layer**

The interaction layer is the system’s front-end. The web interface is the part of the system that comes to direct contact with the end user providing access to system content and services. Users can interact with it using any commercial web browser. An advantage of this approach is that it is widely accessible without requiring the use of some specific software on
the user side. It also enables communication and collaboration among users through resource sharing using various utilities such as tutor and student forums, bulletin boards etc.

SYSTEM AND USER SERVICES

The functionality supported by LearnCom (depicted in Figure 2) can be divided into system services and user services with the web interface interpreting system services to user services and vice versa.

![Figure 2: Service categorization](image)

More specifically, system services comprise:

- **Directory services**: LearnCom manages system documents (such as pictures and web pages that are represented as files arranged in folders) using directory services. The directory supports file upload and download.

- **Security services**: the security module is responsible for managing authentication and confidentiality. The former identifies users that access the system and the latter verifies
that parts of information are restricted to specific user groups. Authentication service is a group based service in terms of access to resources.

- **Remote Management services**: they grant specific user groups several administration tasks that can be performed using any web browser. For example, the system offers administrators the ability to accept or reject a new user account request and tutors the ability to modify the schema of their learning modules.

- **Communication services**: the system offers both synchronous and asynchronous communication between the groups of users, via several alternatives such as the Forum, the Chat, etc.

- **Search services**: information maintained in LearnCom is both diverse and constantly increasing. Thus, in order to enable fast identification of the information of interest on the user side, incorporation of search was a necessity. Searching scans not only the content of learning modules, but also all data supplied by users in the form of questions submitted to tutors, answers to student questions that tutors have made public, messages exchanged in the forums, etc.

- **Assistance services**: a “Questions & Answers” section is available for students to find answers to frequently asked questions. The system provides special forms to students for submitting a question, forwards all pending questions to a place all tutors can access and informs them that there are questions they might want to answer. Tutors can either send their answer directly to the student that submitted the question or -in the case that the question is of general interest- post the question and answer pair to the homonym system page for all students to see.

- **Customization services**: LearnCom was designed in a way that enables easy and fast language customization. This customization distinguishes user groups based on the language of their preference, in the sense that there is no practical reason for a student that
does not speak English to have access rights to the Chat that English speaking students use. This feature led to the need for reassuring system expandability and arranging so that LearnCom is able to support more than one community (so far, two independent communities have been shaped using language as the distinctive characteristic). English is the basic system language but the user interface and the modules content can be easily adjusted to support any language provided that an equivalence glossary and the translated content files are available.

User services are distinguished in Table 1 by the profile they regard (administrator, tutor, or student). More specifically, user services comprise:

<table>
<thead>
<tr>
<th>ADMINISTRATOR</th>
<th>TUTOR</th>
<th>STUDENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manage student and tutor accounts</td>
<td>Upload and position new topics in existing lessons</td>
<td>Read or download learning topics</td>
</tr>
<tr>
<td>Allocate profile privileges</td>
<td>Create and position new lessons/skills</td>
<td>Print lessons</td>
</tr>
<tr>
<td>Configure and customize the system</td>
<td>Answer pending student questions</td>
<td>Update or view personal progress</td>
</tr>
<tr>
<td></td>
<td>Exchange messages using the Forums and the Chat</td>
<td>Exchange messages using the Forums and the Chat</td>
</tr>
<tr>
<td></td>
<td>Add or view announcements</td>
<td>Read questions and answers</td>
</tr>
<tr>
<td></td>
<td>Update the glossary</td>
<td>Submit questions</td>
</tr>
<tr>
<td></td>
<td>Upload recorded video lectures</td>
<td>Watch recorded lectures</td>
</tr>
<tr>
<td></td>
<td></td>
<td>View announcements</td>
</tr>
</tbody>
</table>

*Table 1: Services corresponding to the user profile*
• **Student oriented services:** LearnCom, by definition, supports a set of learning module related capabilities, along with multiple assistance options, search facilities and a number of additional services. Learning content on a specific subject (e.g. MS Word) is categorized in a number of lessons (e.g. Document formatting) and lessons are broken down to a series of topics (e.g. Borders and shading). A student can either read and download specific topics, or print all topics comprising a lesson (a special mechanism dynamically generates and formats a new web page containing all topic files for the student to print). Moreover, students can mark the topics they have studied and store them in their personal progress record. Topics marked as read, display an informative message to the student suggesting to move on to an unmarked topic. The progress record is accessible to the student in order to have an overall picture of the individual progress accomplish so far. Assistance options vary so as to satisfy different needs. Help provides information on system features, functionality and the suggested learning process. Glossary is aimed at clarifying terms that appear in the learning modules and relate to the specific context. Students can submit a question that will be forwarded to and answered by the respective tutor/s receiving this way assistance on specific issues. Students can also view the Questions & Answers page, in order to find answers to frequently asked questions. Communication and collaboration is fostered via the Chat and the Forums. Additionally, students may watch video lectures recorded during face-to-face class sessions.

• **Tutor oriented services:** tutors can manage learning modules through a web interface. They can structure and upload a module or parts of a module and also update the glossary with a new term or an additional definition to term already defined. Moreover, they can post recorded video lectures (in any video format), as well as text announcements for all community members to see.
• **Administrator oriented services:** system administrators accept new account requests from candidate tutors and students. All student accounts are automatically assigned a pre-defined set of privileges while tutor accounts may differ in terms of allocated access rights. For example, a tutor may be assigned the right to determine the teaching scenario that will be applied to a student or a group of students, which is not the default as this is an administrative task (for more information on the available options and the parameters that can be tuned, please refer to the next section).

PERSONALIZATION: LOOKING UNDER THE HOOD

This section focuses on selected implementation issues and decisions aiming at upgrading the overall learning experience by allocating more power to tutors and students and humanizing the feeling of belonging to an electronic community.

*Graphical coding of student activity level*

This approach was taken on the assumption that the system should foster a mechanism for rewarding the active participants of the learning process, allowing the positive distinction of certain students by displaying a number of stars beside their nickname appearing in the communicational areas of the system. The maximum number of stars (corresponding to available scaling levels, along with the actual function that allocates students a certain number of stars) can be determined by administrators or empowered tutors (that have been by assigned this right).

For each student in the system a record is maintained for storing profile and usage data. Usage data collected using cookies and server log analysis are currently used to calculate and deliver the adequate number of stars characterizing each student, but can also feature as a quite descriptive source of data for assessing the overall user activity on the part of the tutor. Administrators can tune the calculations of student “rewarding” to match any didactic scenario. Scenarios can be based on a weighed combination of various metrics, such as time
connected, material coverage in the form of completed topics (and performance on evaluation tests if available), number of messages posted to the Forums, number of questions submitted, etc. Material coverage $C_{i,j}$ regarding skill $i$ for user $j$ complies with customary coverage definitions:

$$C_{i,j} = \frac{|R_i \cap R_{i,j}|}{|R_i|} \quad (1)$$

In (1), $R_i$ is the number of all available topics in skill $i$ (e.g. all topics in the MS Word skill) and $R_{i,j}$ is the number of topics in skill $i$ marked as read in the personal progress of student $j$.

**Determining system views based on the user profile (administrator, tutor or student)**

As discussed earlier, available options in each profile vary. While administrators are offered the complete set of options and functionalities (in the form of hyperlinks that lead to content or account management forms), tutors have a comparatively smaller set of options, since they do not have access to account management forms, neither to personal account data. Students can access an even smaller part of options, since they should not be able to interfere in composing new course material or altering the existing modules, neither in determining the underlying recommendation mechanisms. Views are determined using simple filtering and implemented using link hiding (e.g. neither students nor tutors see the hyperlink “See pending new account requests”, available to administrators).

**Topics Recommended based on the student community**

Students receive recommendations for further study based on association rules mining: topics marked as read in the progress of students that have also read the current topic are recommended under the “Students that read this topic also read…” section. Association rules (Agrawal and Srikant, 1994) are used to capture the relationships among topics based on co-occurrence patterns observed in the personal progress during successive student sessions. As Han and Kamber (2001) formally put it, the *support* of an association rule refers to the
percentage of the progress records (in our case) for which the rule is true. For association rules of the form “$A \rightarrow B$”, where $A$ and $B$ are sets of topics ($A$ is the set of topics in the current student’s progress, and $B$ is the set of candidate topics to be recommended to the student), support is defined as:

$$support(A \rightarrow B) = \frac{\text{# progress Records containing both } A \text{ and } B}{\text{total # of progress Records}}$$ (2)

A certainty measure for association rules of the same form is confidence. Given a set of recorded studied topics $A$ (in student progress records), confidence is defined as:

$$confidence(A \rightarrow B) = \frac{\text{# progress Records containing both } A \text{ and } B}{\text{# progress Records containing } A}$$ (3)

For example, the association rule:

$$\{\text{topic123, topic34}\} \rightarrow \{\text{topic15}\} \text{ [support=0.02, confidence=0.68]}$$ (4)

conveys the relationship that students who read topic123 and topic34 also tend (with a confidence of 68%) to read topic15. The support value represents the fact that the set $\{\text{topic123, topic34, topic15}\}$ is observed in 2% of student sessions recorded in all personal progress records. Association rules mining (Wang et al, 2002) typically identifies URI references recorded in server logs on a per-session or per-transaction basis and requires log analysis in order to derive sessions/transactions and then references to URIs of interest, but in our case the personal progress provides a more secure and less demanding (in terms of required processing) option, since we indeed want to recommend topics actually studied and not just accessed by other students. Recommendations returned to the user depend on the minimum support and confidence values set by administrators, as well as the preferences of
the current user account (users specify the maximum number of recommended topics or even disable recommendations).

*Topics Recommended based on associations defined by tutors*

A second set of recommendations is generated and placed under “Your tutors suggest that you also study…”. For calculating this list of recommended topics, it is required that when a tutor uploads a new topic, context links are defined towards topics that relate to the concepts and terms encountered in the new topic. These connections are then used by the system to determine the recommendations list for the students that will study this topic.

LEARNCOM IN THE REAL WORLD

During the last three years LearnCom has been used in real life conditions. Three different communities have been created and they are still operating. These communities have been kept independent, since their characteristics differ; one community consists of a group of unemployed people that want to increase their skills and get a job, the second one consists of students in a vocational center and the last one supports the students of the Hellenic Open University in “PLI 10 - Introduction to Informatics”\(^2\). So far all three communities are supported by 125 topics in computer skills and language skills. The communities consist of 189 students in total with ages between 17 and 49. All communities are also supported by periodical face-to-face meetings once per two months, where students have the chance to meet their tutors, ask specific questions about the curricula, discuss their progress and receive support in their effort to keep on learning. It is important to stress that during these sessions no face-to-face traditional training is performed.

For the time being, there are no available data on the comparative efficiency of LearnCom, since the communities do not receive any face-to-face training. The members of all communities do not have the financial support to move to a specific place for training and they reside at different regions in Greece, so LearnCom is their only choice. At the end of
each year, all students have to give exams in an examination center in order to receive
certification for each successfully completed module. The average success rate (i.e. the
number of registered students divided by the number of students that passed the exams) is
64%. But since not all registered students manage to qualify for the exams (due to drop outs
for personal reasons), the actual success factor (i.e. the number of students that qualified to
give exams divided by the number of the students that succeeded at the exams) climbs up to
96%.

CONCLUSIONS AND FUTURE WORK
In this paper we presented a dynamic web-based learning environment that can be used to set
up and support the operation of online learning communities. The system experiments with
various adaptation methods in order to deliver personalized content and better cope with
diverse user profiles, preferences, goals and needs. Accumulated community knowledge and
experience is extracted from the recorded personal learning history of the community
students and then combined with the tutors’ domain expertise and didactic experience and the
activity level of each student, results in the production and delivery of personalized system
views to community members.

Concluding, e-learning demonstrates great opportunities. But it also presents great risks. The
presence of anytime, anywhere learning via the Internet suggests that online learning can be a
popular alternative for many students who do not have the opportunity to attend traditional
face-to-face classes or who prefer the independence of this method of education. Regardless
thought, of how many and how intelligent techniques technology offers for delivering online
teaching and learning, or how sophisticated, integrated and highly customizable e-learning
systems become, the fact remains that as the novelty effect of online courses wears off, online
learners may become less tolerant of poor online course experiences (Rovai, 2002). To be
successful, experienced instructors are required to have the knowledge and skills to elicit
student satisfaction and the creation of the feeling of being members of a virtual community is a strong force towards this end. For shaping communities out of a group of people that participate in the same e-learning environment, developers and users must plan, guide, and mold communities to support the people in them. Like twentieth-century town planners and architects, community developers can profoundly shape the online community landscape. Attention to sociability and usability will be a big step along the way to ensuring development of successful online learning communities.

We plan to proceed with future versions of the system focusing on allocating more power and flexibility on the tutors’ part, so that different –or even multiple- teaching scenarios can be applied for diverse student profiles. For this purpose, we must incorporate mechanisms for allowing tutors basis to set prerequisite topics on a per-topic and this way provide advanced forms of adaptations (like for instance, guided navigation support). Another thought is to work more on the techniques for acquiring recommendations and introduce a topic ranking procedure for students that will allow for collaborative filtering and clustering approaches.

REFERENCES


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1 Increase in the value of support means that a set is represented in more personal progress report records. Based on the definition of support, it is independent of the number of topics available.

2 PLI 10 is one of the course modules of the Hellenic Open University. For the definition of each module and the structure of the Hellenic Open University, please refer to http://www.eap.gr.