Enticing Learners to Mathematics through A Ludic Collaborative Learning Environment

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Abstract

A Ludic Collaborative Learning Environment is introduced as an auxiliary system to motivate learners into mathematics through Recreational Mathematics. Our system can be used by instructors either on face-to-face or distance courses, while a learner follows normal curricula activities. The collaborative framework provided by the learning environment, gives the learner the possibility to resolve jointly complex mathematical problems. Also, the learning environment has the capability of embedding either proprietary or external content by means of several mechanisms, HTML legacy content, table of contents of entire sites, embedded math games. Our approach is an effort to diminish learner apathy toward mathematics, showing not only their useful aspect in daily life, but also that learning mathematics can be a fun experience that can influence their life.

1. Introduction

We present a collaborative learning environment based in what we have called Interactive Instructors of Recreational Mathematics (IIRM), as an innovative aid for face-to-face and distance courses. Our approach is based on using recreational mathematics in formal education, to achieve a better understanding of mathematical concepts on problem-oriented courses [Averbach and Chein2000][Steen1999][Klawe and Phillips1995]. This WWW-technology Learning Environment, provides the user with a fully customized workspace composed by independent elements that present mathematical concepts in a friendly way such as riddles, math problems, simulations and games, and a set of collaborative tools. These independent elements use several hypermedia sources: text, animations, video and interactive software. They can be chosen by the user, or suggested by an instructor, according to the activities assigned in a classroom, a laboratory or at home. The learning environment also provides different integrating tools such as membership, providing the user access to their personal session, their personal home page, and providing the capability to interact with other users, by means of several collaborative subsystems like electronic mail, instant messenger, chat rooms and multiuser math related workspaces and games.

2. The Interactive Instructor of Recreational Mathematics

The Instructors of Recreational Mathematics represents the conjunction of pedagogical models and recreational mathematics, to stimulate abilities related with the acquisition of mathematical concepts. When these Instructors are introduced into the computer, we add two important components to the model, telematic related technology and a computer based ludic environment. In this way, the Interactive Instructors of Recreational Mathematics (IIRM) are defined as an educational software component, distributed or not, specialized on mathematical concepts in a recreational mathematics context. One or more individuals can interact with each other or with the IIRM with the purpose of generating mathematical thought. A more detailed explanation can be found in previous work [Lopez Morteo and Lopez Mariscal2000][Lopez Morteo et al.2001][Ibarra Esquer et al.2001]. Since each IIRM is an independent module, they can exists by itself without a specialized computer environment. They are presented as web pages containing text, images, video, interactive dynamic elements, or Java embedded applications. Because of this, we can distribute instances of IIRM on-line, CDROM or any storage media. However, this kind of solution does not fulfill our requirements of an integrated virtual workspace for learning mathematics. So we extend our model from isolated elements contained on an WWW-technology system to a set of fully interconnected elements, interacting with each other, the user and the environment. With this in mind, we developed a design for a virtual learning environment and built our first prototype called "Los Supersabios" (spanish for super sages, http://azul.cicese.mx/supersabios), honoring the mexican science-fiction adventures comic strip bearing that name (Germán Butze, 1936 to 1978).

3. The Collaborative Learning Environment

3.1. Architecture

We developed our first prototype based on several open-source projects, the most important to us comes from Apache Software Foundation called Jetspeed [ASF2002c]. This project provides a Java based framework to build Internet portals, and contains user membership services provided by another open-source project called Turbine [ASF2002b]. Jetspeed builds the user portal home page from several sources: HTML static pages, dynamic server-side CGI-type HTTP applications (Servlets, JSP, CGI, PHP, etc.), HTML client-side dynamic pages (with JavaScript, Java applets or Macromedia Flash), XML to HTML transformed pages, syndication of content through XML applications and native applications, among others. On the server side, we use the Apache WEB server [ASF2002a] as front end to the application server Tomcat [Tom2002]. Also, we use the database management system Mysql server [Mys2002] as a permanent storage of user information. For the communication layer, we use the Exim mail server [Exi2002] and the Cyrus IMAP server [Cyr2002] to manage electronic mail and deliver messages, respectively. Also we use the Jabber Messaging Server [Jabber.org2002], both as instant messaging system and chat room server between users and applications. All the software are running on a Linux box, but it works as well on a Windows NT systems. Special care

is taken in the usability of the system, hence the user just needs to introduce their login and password once to have access to all the content and services. Because of that, all applications have been modified to store the user information on shared tables on the Mysql database. That is the main reason for the use of open-source projects, since we can modify the source code to adapt it to all of our necessities.

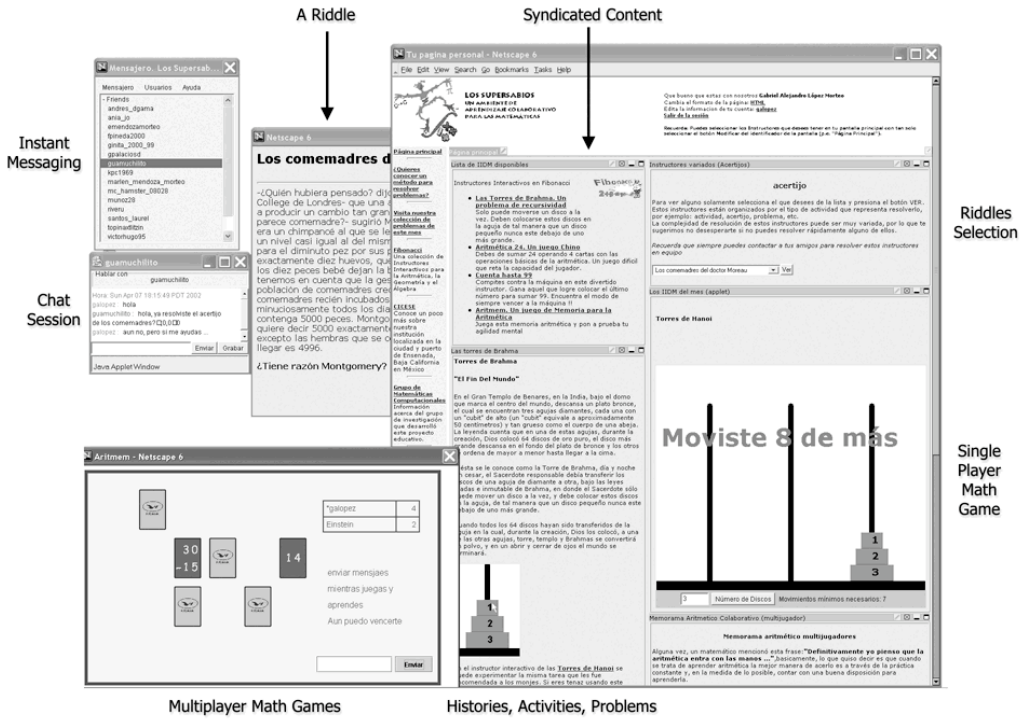

Figure 1: A user request a IIRM (for example a riddle) through a web form. The environment retrieves the XML document and transforms it to HTML and then is redirected to the user browser.

3.2. Flexibility for management of the mathematical content

As we explained earlier, our learning environment can handle several types of mathematical content, expressed by a wide range of sources, from text to embedded applications. This characteristic provides a very flexible tool for an instructor who wants

to create mathematical content. Especially when the instructor already has the material on standard HTML format (legacy content). In this case, the instructor only has to configure the environment with the address of the content (local or external), and the system automatically retrieves it. After that, this content is introduced into the catalog where the user can choose from it. Another property of the system resides on the capability to keep the original structure of the page, even if it includes JavaScript or Java applet applications. The only modifications the system makes on the retrieved content are limited to presentation. The system removes all presentation related contents to maintain the homogeneity of the environment presentation. In figure 1, we show a user desktop with several IIRM, an imported HTML page containing a history about the Hanoi Towers, a couple of Math games, a syndicated content of another system of IIRM developed by us called Fibonacci, a riddle selector, a riddle displayed on a pop-up window and the instant messenger with an open chat session between two users.

This procedure concentrates isolated content on a single catalog. In the case that the material is well structured on another web site (local or remote), the instructor can build a "table of contents" of the web site, by means of a single Extended Markup Language (XML) file. This mechanism is called syndication content, and is based on the Remote Site Summary (RSS) technology from Netscape [RSS2002]. The structure of this file is quite simple, contains a simple description of the whole site, and a list of single elements of the contents defining its title and Internet address. Optionally it can contain an image (site logo) and a form text field. The structure of the XML file is provided by a well known Document Type Definition (DTD), who identifies the tags and data type for the XML file. Once the system is configured it retrieves the file which is transformed to HTML. If the instructor made an RSS file for his own material, another portal can retrieve it, to incorporate it to their catalog. If several systems made this file, and share it with the community, we can build an academic network of thematic mathematical content, where an instructor can increase their catalog with external quality content.

3.3. Different kind of content, different underlying technologies

We now establish a relation between different kind of mathematical content, with an underlying technology that we consider more adequate to support it, according to the nature of the IIRM (riddle, problem, activity, ...), their updating rate (hours, days or weeks), complexity and collaborative structure. These relationships are presented in the following table.

Type of Content	Actualization Rate	Complexity	Collaborative	Technology
Support material	months, weeks	low to high	no	HTML, XML, RSS
Stories	weeks, days	low	no	HTML, CGI
Riddles	days, hours	medium,high	no/yes	XML, CGI
Problems	weeks, days	low to high	no/yes	XML,CGI, E-APP
Math related activities	weeks	medium, high	yes	XML, HTML, CGI
Math games	months,weeks	medium, high	no/yes	CGI, E-APP

In the table, HTML refers to static and dynamic content, XML represents the format of the source files also static and dynamic, RSS refers to syndication content, both local or remote, CGI represents a server-side application and E-APP refers to embedded applications. It is important to remember that all references to the underlying technologies are related with the services provided by the learning environment.

3.3.1. Support material

This kind of content is usually provided by the instructor, e.g. bibliographic reference of the course. Having a long-term life and few changes, this content is better presented by static presentation technologies such as HTML files, XML files and syndication content. These content has to be understood by individual learners, because there is no need for collaborative support.

3.3.2. Stories

This element of Recreational Mathematics can be used as an introduction to several mathematics concepts, putting the learner in a enticing context, preparing it to work with other recreational elements. We consider this element as having a mid-term life due to its introductory character. It might be necessary that it is upgraded frequently in order to maintain the interest. A regularly maintained HTML static web page can be enough to achieve it, but a well designed CGI-type application can automatically update stories regularly.

3.3.3. Riddles and problems

Riddles and problems are a star within Recreational Mathematics. The learners like intellectual challenges and these are always a good way to achieve them. Riddles can be categorized with respect to the complexity, user knowledge level and user skills. In a practical learning environment, their life time could vary from short to middle, to help instructors to keep alive learners motivation with new content in a short period of time.

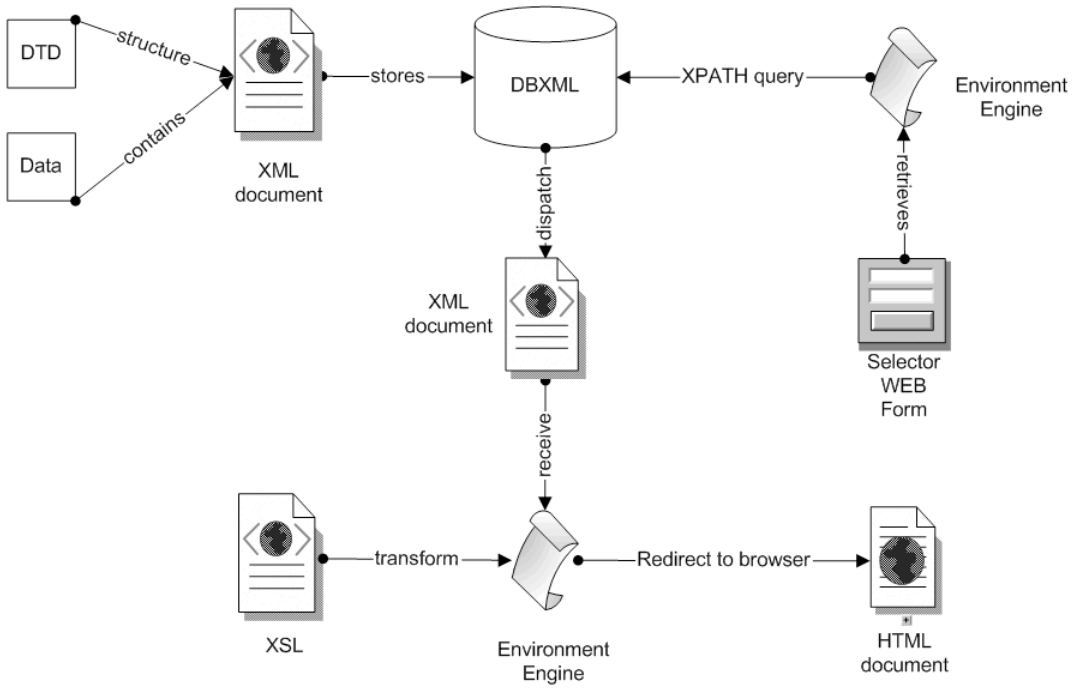

Figure 2: A user requests an IIRM (for example a riddle) through a web form. The environment retrieves the XML document and transforms it to HTML, finally it is redirected to the user browser.

XML based web applications and CGI-type applications, seem to be the appropriate technologies to manage these dynamics. In addition, problems are well supported by embedded applications, by means of simulations, a graphical representation of mathematical concepts and virtual laboratories. Learners can interact with these applications to corroborate their results or test alternative approaches to the solution. We developed a special web application for riddles, problems and activities. We wrote them in XML files, stored in an XML native database management system called DBXML [ASF2002d], recently adopted by Apache Software Foundation with the name of XINDICE. The benefit of the use of this database is that we do not have to map XML to a relational database structure, the data is stored in native format. So we can use the XML Path Language (XPATH) [W3C2001] to make queries to the database and retrieve the appropriate XML document. This query is based on a tag name, tag value or tag property, so it is easy to retrieve a specific XML document. Once we have the XML document, we can dynamically transform it to a desired format, HTML, PDF or plain text, by means of

the Extensible Stylesheet Language file (XSL) [W3C2002], This file is useful not only to transform XML data to a desired format, but also provides a mechanism to dynamically show or hide some parts of the file. This property, gives the possibility of maintaing a single XML data file containing all the information related to a riddle or a problem, title, data, author, keywords, type of content, mathematical concepts associated, images, applets and solutions. Therefore, it is relatively simple to create different versions of the XSL file to be presented to different type of users or at a different time. In figure 2 we show the entire process of retrieving an XML document through this application.

3.3.4. Math related activities

This category could be composed of virtual and physical activities. Ranging from web search to collaborative projects, e.g. counting trees for a statistical spreadsheet. Activities can have mid-term life because of the extension of a particular project. Therefore they are implemented by means of static HTML files, CGI-type web applications and the previously explained XML based application.

3.3.5. Math games

We call math games to either single-user or multi-user applications that implement some game-type activity related to mathematics, based on a pedagogical background. We differentiate this type of games from other math educational games. We follow Papert [Papert2000], in the sense that we try to avoid those without a direct pedagogical value, and those that contain isolated math concepts and are easy to master. We make this distinction, because we want to avoid games that do not contribute to the user learning because their simplicity and fragmentation of knowledge. For now, we also eliminate commercial-type videogames because their use in instruction is complex to be implemented without previous experience, however they have proven to be useful for teaching (Juanjo Cardenas, personal communication, see [Gros et al.1998]). Some examples of the games that we have developed following these ideas and can be found inside the learning environment are:

- The Hanoi Towers. Learners have to move graded rings from one stick to another, in the smallest number of turns. The conditions are, just one ring move at a time, and a small ring cannot be placed in top of a larger one.
- The Chaos Game. It is based on Sierkpinsky Carpet. The learner needs to make fall a dot into a one "hole" of the fractal carpet, following the construction rules of this mathematical curiosity.
- Add 99. Learner play against the computer choosing one number from 0 to 9 one turn at a time, then this number is added to the previous one. Wins the game the first player who adds 99.
- Arithmetic 24. Given four value cards, the learner needs to operate it with the four arithmetic operations to obtain as result the number 24, before running out of time.

- Tiled mosaics. Learners need to build mosaics with rectangles of different sizes. Every time a rectangle is added, the game calculates the minimum average area of all rectangles on the board. The goal is get the minimum average area without have two adjacent rectangles that they form a subrectangle.
- Arithmetic memory game. Based in the classical memory game, but one pair consist of an arithmetical operation and its result. This game has two versions: single-user version where learner plays against the computer, and collaborative multi-user version when learners can play against each other.

3.4. Transporting single-user into multi-user applications

Due to the amount of educative legacy applications that are already available, we developed a methodology to transport an object oriented single-user application into a multi-user collaborative application. We want to improve the learner experiences, by means of interaction with their partners, through collaborative math games. In our methodology, the learning environment architecture provides mechanisms to support the exchange of messages and events between distributed applications. This exchange is necessary to maintain synchronization between interfaces, data and the state of the applications. We developed the collaborative version of the Arithmetic memory game following our methodology, and we are in the process of translating some of our other single-user games into, multi-user collaborative games. The details of this methodology are beyond the scope of this paper, and it will be available in [López Morteo2002].

4. Conclusions

We presented our Internet based ludic collaborative learning environment "Los Supersabios", as an aid to entice learners to mathematics. We do this through our Interactive Instructors of Recreational Mathematics. We believe that this learning environment provides instructors, with wide and flexible mechanisms to present, both new and legacy, mathematical content without too much additional effort. Introducing computer supported Recreational Mathematics content into the formal learning process, requires that instructors adapt their content to present the friendly side of mathematics. A lot of this kind of content can be found in books and elsewhere, on-line. Thanks to the capability of embedding external material into the learning environment, we can use it keeping copyright information, page layout and presence (e.g. logo images) like in the original source, changing only presentation of colors or font size. Even if we cannot modify presentation aspects of the original source, we can still use it through syndication content services. The collaborative framework provided by the learning environment, gives the learner the opportunity to interact with their partners to resolve mathematical problems jointly, as well collaborative tools can be used in a social context to create personal relationships between learners that could stream into the generation of a virtual community. "Los Supersabios " (http://azul.cicese.mx/supersabios), represents an effort to diminish learner apathy toward mathematics, showing not only their useful aspect in

daily life, but also showing that learning mathematics can be a fun experience that can have a possitive influence in their life.

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