HIPPODAMUS: A WWW Based Expanded Learning Environment

Georgios Kouroupetroglou, Constantinos Viglas, Alejandro Pino
koupe@di.uoa.gr, cviglas@di.uoa.gr, grad0152@di.uoa.gr
National and Kapodistrian University of Athens, Department of Informatics,
Laboratory of Speech Communication, GR-15342, Athens, Greece

Despina Deligiorgi and Ioannis Kalogiros
despo@cc.uoa.gr, jkalog@dap.uoa.gr
National and Kapodistrian University of Athens, Department of Physics,
Laboratory of Environmental Physics, GR-15342, Athens, Greece

Abstract: This paper discusses the theoretical model, the design, and the implementation of a learning web entitled HIPPODAMUS, namely a cluster of interactive networks of persons and technological networks which harmonically collaborate with the aim to perform effective learning. The technological networks include the equipment for supporting the studies of the students (e.g. specific measuring instruments or networks of sensors) as well as the technology for supporting the learning process (such as computer systems and networks and especially the Internet). HIPPODAMUS constitutes an expanded learning environment that incorporates extensive use of the Internet and its services, effectively promoting the active participation of all the partners involved in the educational process, namely of students, teachers, academic / research community and the administration of the education. This web is based upon the use of information and communication systems built for the World Wide Web, and it constitutes the application of an experimental educational framework on subjects such as Informatics, Technology and Environmental Education. HIPPODAMUS ties with the current trends and requirements, concerning the joined preparation of high-school students towards the Information Society, the Learning Society and the Environment-aware Society.

Introduction

During the last years, the educational community has faced the boom in computer science and communication networks with special emphasis on the Internet. This has led to significant evolvement in software dedicated to educational process support systems (Edwing et al. 1999). At the same time, a considerably easier access to information sources is available (Gilliver et al. 1998). The design of a modern educational system is based on appropriate support systems for both the teacher and the student, which facilitate the access to information (Astreitner et al. 1998), such as databases, electronic dictionaries and online educational aids (Kraus 1995) (Metaxaki et al. 1999). In this context, the basic constituents of an efficient learning system for science education are:

- Accessibility to sources of raw and processed scientific information.
- Use of unified and interconnected educational content and open architecture for the presentation and analysis of scientific phenomena as well as their computation and assessment.
- Development of innovative learning techniques, computational methods and supplementary educational content as well as their integration in the unified and interconnected educational infrastructure.

Furthermore, we are interested in the general aims of an efficient educational system, such as:

- Redefinition of the teacher's role, with their participation in the design and practice of innovative educational methods.
- Update of school knowledge and didactic content.
- Improvement of the educational results.
- Setting higher standards in didactics on scientific and technical matters.
- Student's social sensitization through the introduction of novel pedagogic practices, the application of interdisciplinary scientific methods and the use of new technologies in education.
- Broadening of school's social role and involvement in local society's activities.
- Environmental sensitization.

Theoretical Model

The contemporary trends for an effective educational system demand the development of new educational methods, where the *student becomes active participant and creator,* and the development of an efficient communication way between the different and heterogeneous groups that participate in these new learning processes.

Based on the above principles, in this paper we present the design and implementation of an innovative educational approach, which is reliant on the *Learning Web* model (Kouroupetroglou et al. 1996), namely a cluster of interactive networks of persons which harmonically collaborate through appropriate technological networks, with the aim to perform effective learning.

We define the *learning environment* as a system that involves:

- The students that, with the help from their teachers, study the real world in terms of local and global problems, through appropriate learning activities.
- The technological equipment for the supporting the educational studies (e.g. specific measurement instruments).
- The technological equipment which supports the learning process (e.g. computer systems and networks, the Internet).

A learning environment should be able to collaborate with other learning environments in national and international level. In that case we refer to *interactive* learning environments.

The *expanded* learning environment involves not only the users (students – teachers) but also the persons who maintain, support and improve the system, either scientifically or technologically. Therefore it is a cluster of networks of persons and technological networks.

The structure of the Learning Web model (i.e. the expanded learning environment defined above) must be open and must support the integration – incorporation of heterogeneous subsystems. The Internet can be the basic communication medium between the *interactive* learning environments as well as the basic source of educational content.

Design

The application of the Learning Web model we have developed in the domain of the *environmental education* was named HIPPODAMUS [1]. The experimental application is based on the construction of a network of automatic weather stations for the measurement of atmospheric parameters at the school location, and the creation of a centralized database related to these measurements. Using World Wide Web communication means, we developed a methodology for the acquisition, retrieval and didactic presentation of the raw data and metadata so that the student understands the natural meaning, interaction and influence of atmospheric measurements.

The general objectives of HIPPODAMUS learning environment are:

- Development of new teaching and learning capabilities through:
  - ✓ Search for knowledge in multiple sources (with emphasis to electronic sources).
  - ✓ Active student participation in learning process.
  - ✓ Active student participation in real measurements analysis.
  - ✓ Students cooperation in the class and between different schools.
  - ✓ Electronic communication between students from different schools, but also between students and scientists and experts.
  - ✓ New methods of educational content distribution to the teachers.
  - ✓ Increased (electronic) communication between teachers and scientists or experts either in the field of education or administration and design.
  - ✓ Creation of an electronic forum for the teachers to cooperate and exchange experiences and educational content.
- Systematic introduction in the curriculum of secondary schools of a course involving Informatics, Technology and Environmental Education with an interdisciplinary approach.
- Obtainment of real experience on informatics and Internet's applications and services.
- Interconnection of scientific and local society with the educational process, and reinforcements of the school's bonds with the local society.

According to HIPPODAMUS system's design, the participants (students, teachers and scientists/experts) accomplish the following activities:

[1] HIPPODAMUS *Pronunciation:* [hipod´*u*m*u*s] 5th cent. B.C., Greek architect, b. Miletus. He was the first to plan cities according to geometric layouts. For Pericles he remodeled Piraeus (the port of Athens). He also planned (408) the city of Rhodes and went with the Athenian colonists to replan (c.440) the new city of Thurii in Italy. Other cities of the ancient world followed his methods.

Students: take measurements of atmospheric parameters at their school's area using the automatic weather stations and share these data with other students and scientists via the Internet. Through specific learning activities they study the weather, and try to explain the phenomena that they observe in the atmosphere. They relate their observations with local environmental problems and compare them with the data at other locations. The continuous and broad measurements give the opportunity to the student to comprehend useful terms such as the mean value, the standard deviation, the correlation, etc. Students communicate through the Internet with scientists to learn about weather, environmental and atmospheric matters, and they use the capabilities of computer systems and the Internet for a variety of different applications. Finally, they participate in the evaluation of the system.

Teachers: guide students to acquire measurements and to use the computer systems and the Internet. They help students to understand the meaning of the measurements and explain the importance of data visualization. They also communicate through the Internet with scientists and colleagues to discuss atmospheric and weather matters. Finally, they use the capabilities of the technical equipment for a variety of different applications and they participate in the evaluation of the program.

Scientists: and *experts* develop the educational content for teachers and students as well as the software for visualization and analysis of the data for the students. They develop and maintain WWW pages for the project, train the teachers and support teachers and students through e-mail, chat sessions, web-conferences, etc. They finally participate in the evaluation of the program.

Scientists: Educators of Design and Administration participate in the design of the educational process, and carry the responsibility of selecting which schools will participate in the program. They facilitate the realization of the program and have constant communication with scientist and experts. They also participate in the evaluation of the program.

Implementation

The Learning Web of HIPPODAMUS is based on schools interconnection through the Internet, the systematic conducting of atmospheric measurements with a weather station and the exploitation of these measurements in learning processes. For its implementation, the *necessary equipment*, the *appropriate software* and *educational content*, the *teachers training*, the *experimental application in the classroom*, the *technical and scientific support* of the schools and the *evaluation* of the educational system, have all been researched, designed and developed.

The computer and communication system of HIPPODAMUS (Fig. 1) virtually serves three target groups: *students*, *teachers* and *scientists*. It provides the following services:

- Input and storage in a central database of the measurements that schools collect from automatic weather stations.
- Access and distribution of the data in order to analyze and compare.
- Data and metadata visualization.
- Student communication with other schools and experts.
- Educational content distribution.
- Discussion and opinion exchange between teachers.
- Presentation of the program on the World Wide Web.
- Technical support on computer, technology and environmental matters.

In HIPPODAMUS framework, acquisitions of various measurements of atmospheric parameters take place. We want to store these data keeping information about their time and location. Furthermore these measurements have to be exploited for the creation of graphical representations, which will be available on the World Wide Web. The Web will also be the interface for the access to the data and the requests for data visualization. These characteristics lead to the construction of a Database, which meets the specifications (Date 1996), and of a corresponding Database Management System with Web publishing and access capabilities.

The system was designed in such a way that it wasn't necessary to store any graphics in the database. All the data visualization is dynamic and created in real time. The Database is located at the Application Server, where all applications developed for HIPPODAMUS run. There is also a different machine, which is a Web Server, in constant and high-speed network communication with the Application Server. The cooperation of these two servers makes possible both updating and querying the Database.

The parameters that the weather station measures include mean hourly values of temperature, humidity, atmospheric pressure, rain, wind speed and wind direction. Student's presence is not required during the weather station's measurements, but they make observations on clouds (cloud type and coverage). The parameters above are fundamental for the weather prognosis and climate determination and give important information about the atmosphere.

HIPPODAMUS include a series of manuals and educational content that has been developed during the implementation of the program (Hippodamus 1999). These provide to the participants the means to understand the operation of the system and perform the learning activities. They are all available online through the WWW. Learning activities include Database updating. Students perform the update in two ways, so that they can gain broader experience in computer systems and communications.

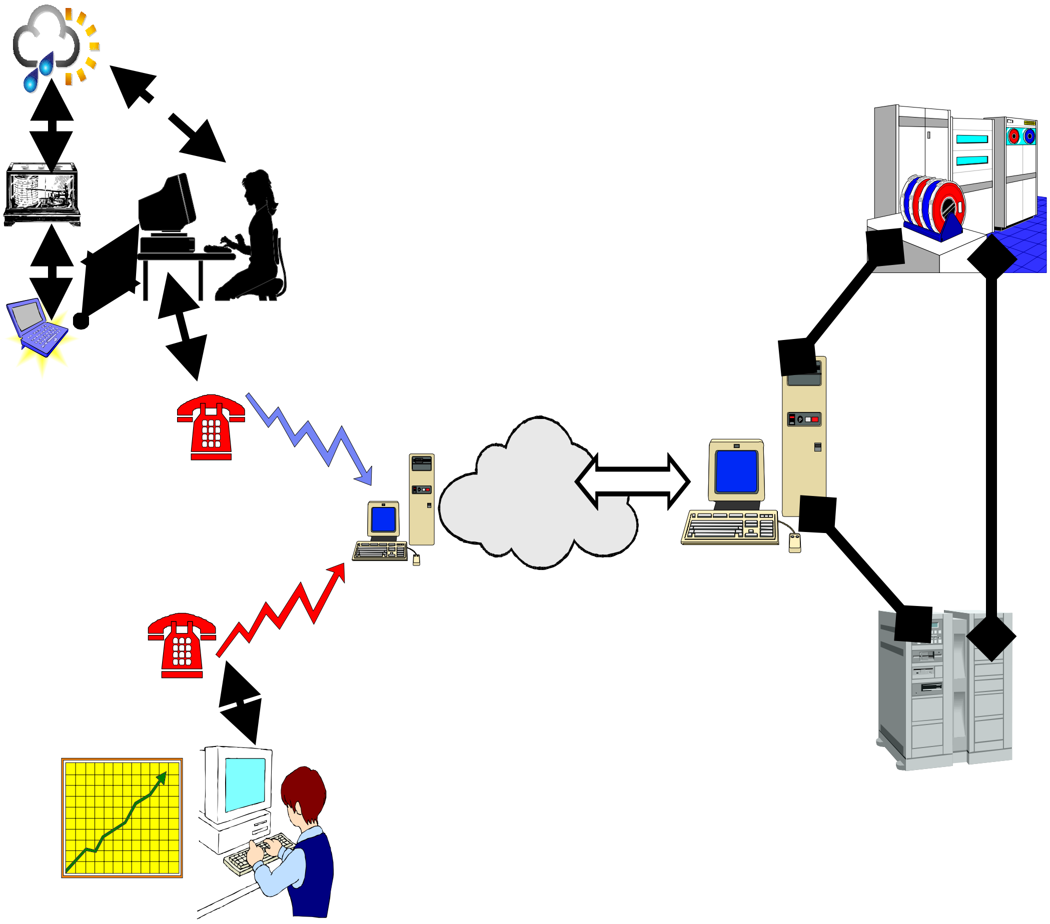

Figure 1. The computer and communication system of HIPPODAMUS

First, all measurements acquired from the Automatic Weather Station are downloaded locally on the student's computer (which is connected to the Weather Station through the serial port). Using the Weather Station's software, students can view, analyze and make chart of their own downloaded data. They are also able to export all or part of their data in an ASCII file, which they send to the Application Server using a simple FTP application. This application has also been developed especially for the needs of HIPPODAMUS. From this point the Application Server takes over and updates automatically the Database with the new data.
Second, as far as the cloud data are concerned, the update process is manual. Using a special Web page, students insert dates and values (cloud types and sky coverage percentages) of observations in a form and submit it to the Web Server. The Web Server updates the Database with these values and dates and responds with an acknowledgment. Both ways of Database Update are Password protected.
Learning activities focus on exploitation of the measurements contained in the central database. We give emphasis on creating and studying time series in order to draw out useful conclusions that help in theory comprehension. We use charts of the measured parameters, which, without implicating obscure mathematics equations, they explicitly show the qualitative behavior of the atmospheric parameters. These charts are available on the Internet, dynamically generated online and in real time by a Dynamic Web Application (Fournier 1999) that run on the Web Server using Active Server Pages (ASP) technology (Johnson et al. 1997).
The WWW pages of HIPPODAMUS are virtually the user interface for accessing the database system. Users submit a wide variety of queries in appropriate forms on the Web and receive charts as answers. Students are using their Internet browser to retrieve the charts, which help them to analyze their data, combine them or compare them with other schools data. The server is able to create in real time charts combining data from multiple schools, multiple parameters, simple or multiple time series, histograms and correlation diagrams, depending on the specific queries that it receives (see Table 1). These charts are published on the WWW, in HTML pages, which are constructed automatically at that time, and received by the user who submitted the query. A variety of prepared learning activities, require students to acquire these charts from the Internet and study them extracting useful conclusions.

Data Visualization		
Time Series (Charts)	One Station Data	Hour Variations
		Day Variations
		Month Variations
		"Average Day" Variations
	Multiple Stations Data	Hour Variations
		Day Variations
		Month Variations
Correlation Diagrams	One Station Data	
	Multiple Stations Data	
Histograms	Percentage Distributions	
Tables	Data Tables for any data, any stations	
	Degree Days	

Table 1. Chart and diagram creating capabilities of the HIPPODAMUS' visualization engine

The Visualization Engine requires the user's (student's) active participation, and is described in more detail:
Using the Internet browser interface, the user makes a query to the Database in order to acquire and visualize specific data according to the selections he made. In most cases he has to choose specific dates or periods, stations, and weather parameters in an HTML form. This query is submitted to the Web Server by clicking a button on the query HTML page. As soon as the query is received, the Web Server processes it, formats it and submits it to the Application Server. There, a Microsoft Office Application receives the query, retrieves the data from a Microsoft Access Database and returns them to Excel for further process. In Microsoft Excel all necessary calculations take place, and a chart is created. This chart is published in a new HTML page with other information needed for the answer to be complete. The HTML page is then returned to the Web Server and presented as a respond in the user's Internet browser. At this point, users can save their results in their local hard disk or print them. All this process never lasts more than a three or four seconds.
For the implementation of HIPPODAMUS we used the following tools: Microsoft Visual Basic 6.0, Microsoft Office 97 VBA, Microsoft Access 97, Microsoft Excel 97, Windows NT Server 4.0 (SP 5), Internet Information Server 2.0, Active Server Pages, Webclasses. The servers are PCs with Pentium III 450 MHz, 256 MB RAM, and 13 GB Hard Disks.
HIPPODAMUS system keeps up with the current trends and needs for the preparation of students for the Information Society, the Learning Society, and the Environmentally Sensitive Society, in local and global level.
The HIPPODAMUS project's experimental operation and evaluation is already in progress with the participation of a number of Greek Secondary Schools spread out over the country. The home page URL of the project is www.di.uoa.gr/ippodamos and the e-mail address ippodamos@di.uoa.gr

Acknowledgements

The work reported in this paper was carried out within the framework of the HIPPODAMUS project, partially funded by the program "Schools for the Implementation of Experimental Educational Projects" of the Greek Pedagogical Institute, under the Educational and Initial Vocational Training Operational Program of the Greek Department of Education and the European Union.

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