DIDACTIC TOOLS ON THE WEB FOR STUDENTS AND TEACHERS: THE ISHTAR SERVER

DANIELA LEONE, FRANCESCO-LUIGI NAVARRIA and TIZIANO ROVELLI
Physics Department, University of Bologna
Faculty of Pharmacy, University of Bologna
INFN, Sezione di Bologna, V.le Berti-Pichat 6/2, I-40127 Bologna
e-mail: navarria@bo.infn.it

A didactic project is being developed using multimedia techniques at the Physics Department of the University of Bologna to help both students and teachers. The ISHTAR WWW server comprises several courses on different chapters of physics and a set of tools for helping with the didactical activities. The level of the courses is adapted for students in their last years at high school and in their first years at university, and it is especially designed for students of the life sciences.
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1 Introduction

The Innovative Software for Higher education Telematics Applications R&d (ISHTAR) project [1] is being developed on the Web at the Physics Department of the University of Bologna (Fig. 1). We plan to construct didactic tools for teachers and students in their last years of high school and in their first years at university. The package consists of several parts, which can be used independently: physics-on-line, services-on-line and problems-on-line. The package has been designed for the use by students attending the lecture courses at the same time, but since it has been developed on the Web it is also suitable for students who cannot temporarily be present at the university. The physics-on-line section contains chapters of a physics course [2,3,4] which comprises texts, animations, and on-line graphics, and uses hypermedia techniques to make the product usable by students with different cultural backgrounds in physics and mathematics, and also by one student at different phases of her/his learning process. The purpose of the services-on-line section is to render easier the dialog between teachers and students. Some services are already active, whilst others are still under construction. The active services comprise the automatic construction of the teacher's Web site starting from a *homepage.htm*, which can be produced, for example, with Front Page [5], and an automatic procedure for handling the enrollment of university students for exams and the lists of results of the exams (exams are an important part of the life of Italian universities). The problem-on-line section is more specific and originates from the physics problems given to the students of Pharmacy and Pharmaceutical Chemistry and Technology (CTF) of the University of Bologna during written examinations. The level of the problems is generally quite basic and the skills that are tested are the ability of understanding physical units of measurement and of changing them in a formula, and the ability of solving a simple equation, giving a result numerically correct to three significant digits. An interactive problem page allows the student to enter her/his own solutions, which are controlled by

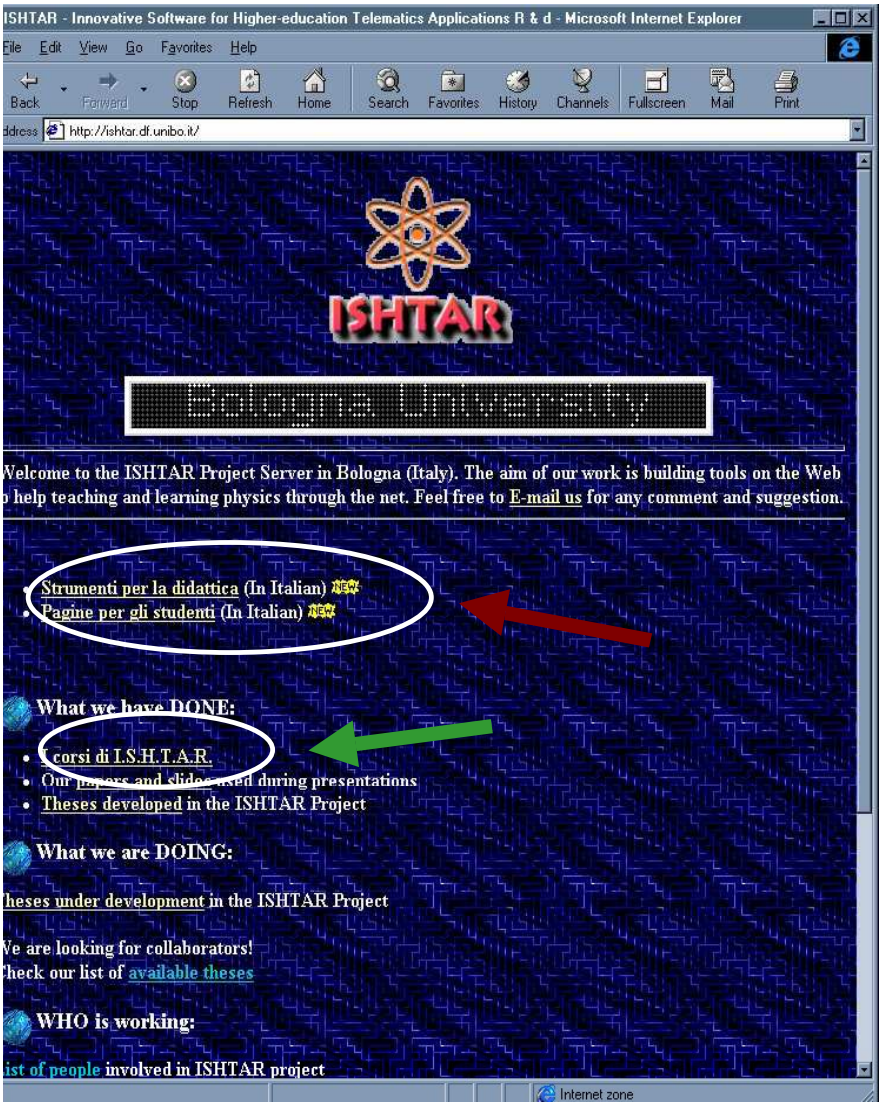

Fig. 1 The ISHTAR Home Page

the server. Since the problems-on-line section is available on the Web it may also be used by students of other faculties or other universities and this is actually the case.

The physics courses are presented in Section 2, the services in Section 3 and the electronic problem book in Section 4. Some tests with groups of students are reported in Section 5. Future development and plans are briefly discussed in Section 6 and the conclusions are given in Section 7.

2 Courses

The courses have been developed over the past few years as part of theses in the didactics of physics at the University of Bologna [2,3,4]. They contain a chapter on the diffusion in solutions [2], one on probability, statistics and measurement errors [3], and one on fluid mechanics [4]. They are in Italian and only the first one has a demo in English. The first two chapters have already been described in this journal [6].

2.1 Diffusion in solutions

The courseware *Diffusion in solutions* [2,6] underlines the experimental aspect of the discipline, but the analytical treatment is also presented. The key point is conveying the notion that the celebrated Fick's law of diffusion is not only valuable as a mathematical relation, similar to other celebrated diffusion equations, by which it was probably inspired [7], but it is in fact also based on experimental measurements [8]. Therefore, animations, interactivity, and the simulation of one particular experiment for the measurement of the diffusion coefficient [9] aim at stimulating the student during the learning phase. Interactivity is based on a particular usage of Common Gate Interface (CGI) scripts [10], in order to maintain the client-server dialog during the simulation. Several Web pages with interactive graphics are needed to discuss a simplified version of a second order partial differential equation, without using higher mathematics. As a result, some students are very pleased with the (simulated) measurements that they can perform and control, and with the resulting graphs.

2.2 Probability, statistics and measurement errors

Probability, statistics and measurement errors [3,6] is a complete course and it is available at two levels: a first introduction to the subject and a deeper and wider treatment for later reappraisal. Both courses can be used per se. Scripts, graphical tricks and Java applets, in addition to FORMs and CGI scripts, have been used both as didactical tools, to ease and render more pleasant the understanding of the subject, and as a way of increasing the participation of the student. Different distributions are generated using random number generators according to parameters entered by the user in FORMs and then displayed graphically. In this way it can be shown easily how sample mean and r.m.s. tend to the mathematical expectations of the distribution as the sample size increases. Also the approximation of one distribution (e.g. a binomial or a poissonian) by another one (usually a gaussian) can be followed interactively, in parallel with the mathematical statements.

2.3 Fluid mechanics

Fluido-statics and –dynamics [4], Fig. 2, is a hypertext organized as a single main trunk, from which stem pointers to different pages, where the subject is treated in a more detailed or more mathematical way, historic references and classic experiments are presented and discussed. At the end of several sections, problems with solutions on the topics just discussed are offered to the students to test their level of appraisal. The subject is clearly of the utmost importance for students of the life sciences, as an introduction to physiology and to some techniques, such as centrifugation, of common laboratory

practice. The mathematical level in this chapter is again limited to the essential elements, even in the expanded sections. Audio files are used to underline some topics, often quoting original work of historical interest in the author's own words. FORMs, CGIs, and Java applets are used to provide interactivity.

3 Didactic tools for students and teachers

We are designing and building some general tools to render easier the publication of hypertexts on the Web by the teachers and the communication between the students and the teachers. Here we will describe the tools available for university teachers and students. So far the service has been used by the Universities of Bologna (Faculties of Engineering, of Pharmacy, and of Phys.Mat.Nat. Sciences) , Brescia (Engineering), Chieti (Economics), Calabria (Engineering), and Florence (Architecture).

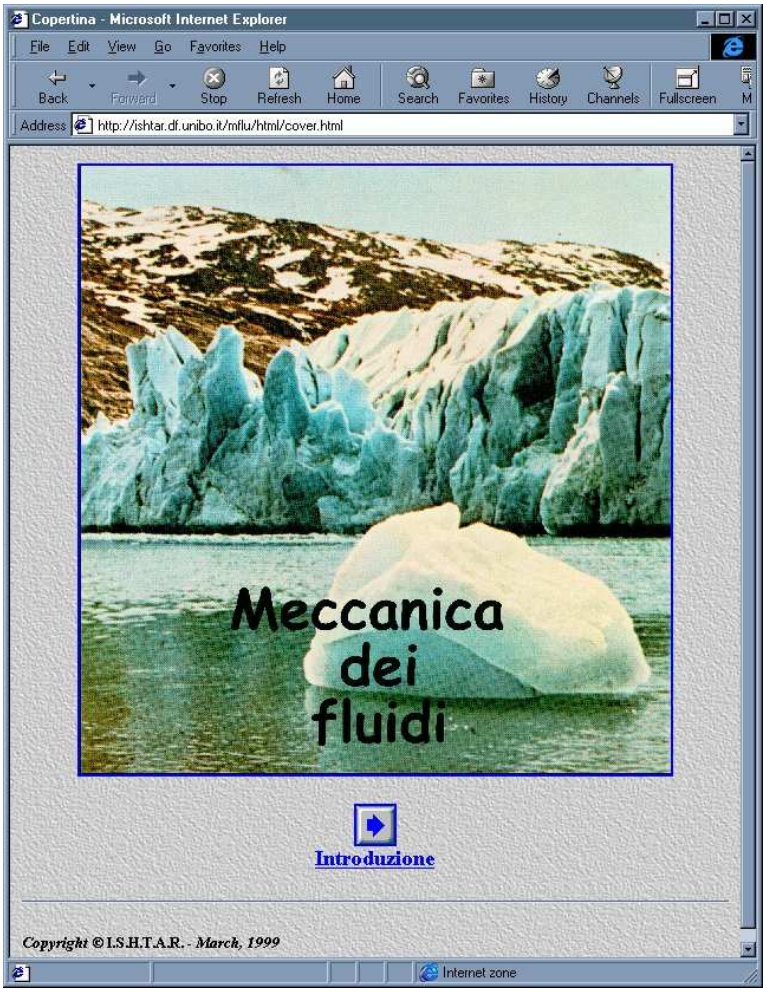

Fig. 2. Front page of the hypertext *Fluid mechanics*

3.1 Teacher's pages

The first time a teacher accesses the ISHTAR WWW server [1], she/he has to complete a FORM for registration. The form contains all the teachers' data (Name, University, Faculty, Subject taught, etc. and also e-mail address to be used in the subsequent dialog with the server), and the teacher chooses a password which is used for later authentication by the server. Upon registration the teacher can use all the services offered by the server. This can be done in a `safe' way, if her/his browser allows it (see Section 3.4).

Each session starts with the authentication by the server: University, Faculty, which can be chosen from a menu, Name and Password identify uniquely the teacher at login time (Fig. 3).

A menu with the available services is then presented to the user. It comprises: 1) building a hypertext, 2) lecture notes (transparencies or PC), 3) customized Web space (introduction), 4) programmes of the lectures, 5) dialog with the students (e-mail archive, FAQ), 6) next session of exams (dates and place), 7) handling of the enrollments for the exams. At present only items 3), 6) and 7) are available to the users.

The management on site of private Web space allows the published material to be immediately visible by the students. The private Web can be produced with standard tools such as Front Page [5]. All file types are permitted, including archives (.zip and .tar), which may be compressed with gzip (.gz).

The tools for the exams on the Web comprise two steps: information about the exam and the opening of the enrollment, and handling of the enrollments and lists of results. To enter the information about the exam, the teacher selects the subject and writes the date and place. She/he also selects the date when the enrollment for the exam will expire and the list of students' names will be e-mailed to the teacher by the server (at 1 a.m. the next day). All the information about the exam can be modified at any time by the teacher and is immediately visible on the Web. It is possible to add a database with the names of the students entitled to enroll for that exam (in a special format). The same teacher can make it possible to see, at the same time, the information about several exams and the relative lists of enrolled students. It is also possible for several teachers to share the same list of enrolled students.

3.2 What the student sees

The student selects University, Faculty, Subject and the Name of the professor and is shown which exams she/he can enroll for. The student has three options: just visualize the enrollments, enter her/his name in the list, cancel a previous enrollment. To enter or cancel, the student must write in a FORM name, first-name and a 10 digit registration number at her/his university; no password is required. The lists visible by the students contain only names and first-names, while the registration numbers are hidden. Also cancelled names are no longer visible on the public list.

3.3 Handling of the enrollment for exams

The teacher can visualize and download at any time the lists of students enrolled, including the information which is hidden to the public, i.e. the students' registration numbers and the names which were cancelled. When the enrollment is closed, the teacher receives the list of students via e-mail. She/he can later modify the list adding, via a FORM, the results of the exam (oral and/or written). In this way the results are immediately visible by the students. Publishing may comprise a quantitative result

(mark), a qualitative result (sufficient/insufficient), some comments: all this information may be entered at different times. All modifications, as soon as they are published, are immediately visible. The automatic handling of e-lists shared by several teachers, each having exclusive access, is also possible.

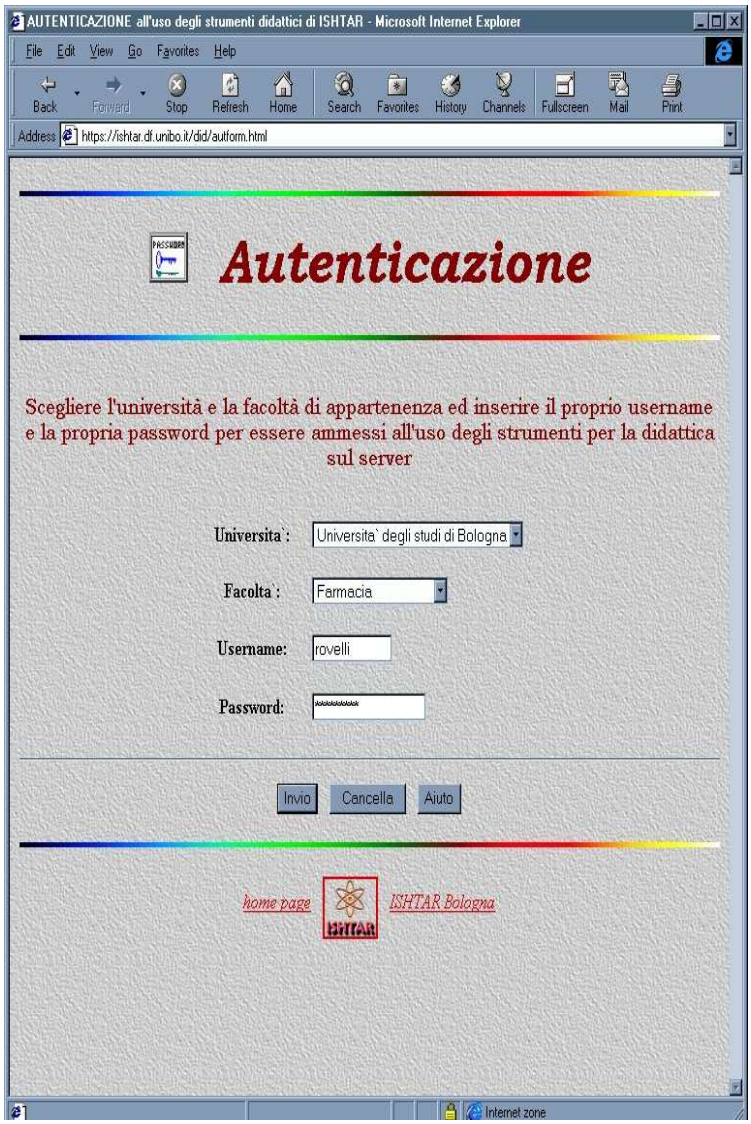

Fig. 3 Form for authentication by the server

3.4 Security

The communication with the server can be cripted using Secure Socket Layer [11] if the user' browser permits it. Access to the server with full writing rights is enabled by a password. A logout button is present in all pages to disactivate the certificate from the

server. A database on the server contains the information about the last work session of the registered user. There is no registration and no password for the public (students) who have their writing rights limited to enrollment.

4 Other tools for Pharmacy and CTF students

Additional tools have been developed especially for the students of Pharmacy and CTF (Chimica e Tecnologia Farmaceutica, Pharmaceutical Chemistry and Technology) at the University of Bologna. An electronic problem book was adapted in 1996 from a version used for the written physics examinations [6,12]. The level of the problem book is adequate for this class of students. The skills tested are solving simple formulae and equations, conversion of measurement units, and calculating the correct numerical solution to three significant digits. The version running on the Web is exactly the same as that used in the examinations. The students can therefore use it to train and test themselves for the exam. Triplets of problems are selected at random from a database, which contains more than 300 different problems covering all chapters of a general physics course. The numerical data are also changed each time with a random number generator; and the corresponding solutions can be obtained by clicking on a button in the problem page. Standard CGI-scripts are used for the electronic problem book, to elaborate the data sent by the user. Data sent from the client are encapsulated in system variables on the server to be used within the script. For training the user can select triplets of problems all from a single chapter, this option may be used also by students when following the lectures to monitor their progress in learning. A fully interactive version of the electronic problem book was developed starting in 1998 [13]: it allows the user to present her/his solutions to the server in a FORM. The server checks the correctness of the results (correct units, correct order of magnitude and numerical value) by calculating the ratio and the difference with respect to the correct value, and writes essential answers with a judgement of the solutions given by the user. Upon request, the formulae relevant to the problem are popped up in Javascript, and a help button is also available to give general advice on how to solve the problems and on how to enter correctly the numerical results.

5 Tests with the students

Tests have been carried out in previous years with Pharmacy and CTF students, on a voluntary basis [14]. Classes lasting typically 2 h, with 10 PCs or workstations, each used by two students, were organized to present the courseware discussed in Section 2 and the electronic problem book. This was done to allow also students without access to the Internet to train and test our Web material. After a brief introduction about computers, content of the courseware, and navigation on the Web, the students were left free to navigate, under the supervision of the instructors, ready to help in case of technical problems or physics questions. Interested students were permitted to attend more than one class.

Questionnaires were distributed before and after each class, and the generic result is that Web modules seem to be easy to use (and to click on) and to understand, even by people with no previous experience of computers and WWW. On the other hand the attendees made an intensive use of the printers, mostly, but not exclusively, because of the limited amount of time during class for an effective study. Some statistical correlation

was visible later between a positive result in the written exam and the fact of having attended the laboratory class. It should not be forgotten however that, since attendance was not compulsory, this might have selected the more motivated and active students.

At the time of the tests (1996-7-8-9), the number of students in that group having regular access to the Internet was still limited. Later the need for dedicated laboratory classes has diminished, since more and more students can access the Web privately, and in any case the number of PCs available for students' use at the university is increasing.

6 Future developments

The physics courseware published so far on the ISHTAR server has been developed as part of the curriculum of physics students graduating in didactics of physics. We would like to continue publishing new courseware on the Web, but this depends on the enthusiasm of new physics students.

As far as services are concerned, we would like to include new tools for teachers such as FAQ's, controlling access via log files for each teacher, and running scripts and/or programs on the ISHTAR server.

7 Conclusions

It is necessary to continue to use and develop Web resources for teaching (physics). WWW modules seem easy to use (and to click on) and to understand. Web services offer a flexible dialog between teachers and students, eliminating in many cases the need for a physical presence, which might be often a problem for students living far from the university. Immediate publication of the Web material is also an advantage.

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