

Teaching by using the combination of a handbook and a website

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Summary

This chapter describes a project for a website that is complementary to a handbook of medical informatics, designed to assist students and teachers in medical informatics. The technical infrastructure of the website and the organizational consequences are described, with special attention given to how international centres can co-operate and how the quality of the information is guaranteed. The website uses a standard browser as a navigational tool and viewer for multimedia information. It contains, besides text derived from the handbook, a glossary, tables, figures, questions and answers, interactive exercises, simulations and demonstrations. A special program, the generator, constructs the hypertext mark-up language (HTML) pages from a database. The specific roles of educational material in a handbook, a CD-ROM and a website are discussed.

Introduction

The use of computers for medical data processing influences patient care directly. It not only replaces old procedures and methods but introduces new tools for 'observation' (data acquisition and analysis), 'diagnosis' (decision support) and 'therapy planning' (protocol management). Computers and information-processing methods are currently an integral part of medical practice. This requires that medical students, who will play an important role in future developments, are familiar with the basics of medical informatics, its applications and the direction of the research. Medical informatics is a rapidly developing field, which requires for its research a close co-operation between medical professionals and computer experts. Therefore, medical informatics is part of the curriculum in many medical schools and faculties of medicine and is quite often a specialization of computer science. The recently published *Handbook of Medical Informatics* [1], written by a host of international experts, is used in many countries for teaching medical informatics.

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Information needs

Handbooks for a fast-developing field such as medical informatics age quickly and require additional information sources for the latest developments and literature. A website could provide up-to-date access to recent research topics and new applications for researchers, teachers and students. Courses in medical informatics for medical students should always stress applicability and practical consequences. This requires multimedia examples and demonstrations of real-world systems.

Educational needs

Medical informatics covers a broad spectrum of topics but centres for medical informatics are specialized only in a few areas. In an ideal situation high-quality teaching could be achieved by combining and sharing knowledge from expert centres. The current trend in present-day education is teaching students skills instead of knowledge. Knowledge becomes the means to achieve a goal instead of the goal itself. Learning skills from a paper book is difficult, if not impossible. Therefore, additional types of educational material are necessary [2], including multimedia (such as audio and video) and computer simulations.

Universities are decreasing the number of oral presentations and are stimulating self-studying. A handbook alone is not sufficient in this case, because it contains only one ordering system, that of chapters and paragraphs, as decided by the editors. Quite often a different view of the material is required and a student will try to locate all parts of the book in which a special topic is addressed. This could be achieved by combining the handbook with a CD-ROM or a website, which allows for an indexed search of key words. Practical exercises to get hands-on experience and questions and answers can also help students to understand the material.

Distance learning is an extreme form of self-study where contact with teachers is minimal. This requires high-quality educational material and a fast and reliable medium for sending questions to and receiving answers from the remote teachers.

The introduction of the CD-ROM for storing programs, data and multimedia presentations was a step forward in supporting teachers and students. A disadvantage of this medium is that the material also dates quickly and requires frequent updates if it is to present the state of the art. Another drawback of CD-ROMs is that each student needs to have a copy of the CD-ROM available.

The Department of Medical Informatics of the Erasmus University in Rotterdam, The Netherlands, started a project to use a website to supply additional teaching material to the *Handbook of Medical Informatics* (at Rotterdam, <http://www.mieur.nl/mihandbook>; at Stanford, CA, U.S.A., <http://www.mihandbook.stanford.edu>). This chapter describes the setting up and current state of the project. Its purpose is to add the facilities of a website to the *Handbook of Medical Informatics* to assist students and teachers. The technical infrastructure of the website as well as the organizational consequences are described. Special attention is paid to how international centres can co-operate to produce teaching material and how the quality of the information supplied can be guaranteed.

Methods

The design of a website involves not only the functional design and the realization of an infrastructure to organize the educational material (the *structure*), but requires also an organization responsible for the development of educational material (the *contents*). This development is a continuous process since the information has to be kept up to date. These aspects are described in the following sections.

Functional design

The website is intended to support the *Handbook of Medical Informatics* by providing alternative ways of access to the educational material of the book and by offering multimedia illustrations and examples. The website is designed to support students as well as teachers. Three different classes of user are distinguished, each with its specific need for information: regular students, who can consult the website as an addition to the handbook and to the courses offered by their teachers; distance-learning students, for whom the website is the primary source of information; and teachers, who can use material on the website for their courses. This implies that information on the website has to be categorized and that different levels of access are required, and if necessary protected by passwords. The specific needs for each user category are described below.

Regular students

Regular students at a university or other school will use the website to get additional and more recent information than offered by the handbook or by their teacher. The website offers an alternative access path to text, tables and figures through a key word index and a glossary. Direct links to other relevant websites, for examples, interactive exercises and demonstrations, give extra information that cannot be presented in a handbook. In modern universities, where self-study plays an important role, other forms of teaching will increasingly replace traditional lectures. A website can help to find and get access to information. Moreover, exercises and questions and answers assist students in testing their own level of knowledge.

Distance-learning students

Postgraduate training with scheduled courses usually involves travelling and interrupts professional labour. A website offering courses intended for self-study may overcome these problems. The number of people studying in this way may rise significantly in the future as the need for better education in the developing countries increases, while schools and universities may be scarce in certain regions. For this user category the website and the handbook are the main sources of information. Teachers are not available to answer questions or to explain unclear parts of the course material. This requires high-quality information and a means to consult teachers remotely.

Teachers

Courses are normally prepared by a small number of teachers based on the requirements of the curriculum and their own knowledge. Teachers are never experts on all topics in their field. The website offers a unique opportunity to share course material prepared by experts. This not only reduces the amount of time needed for the preparation of courses but helps to increase the quality of teaching. Teachers using the *Handbook of Medical Informatics* can use slide shows, illustrations, examples and questions and answers from the website.

Technical design

The website is designed to be complementary to the handbook, which is the basic source of information. Additional information can also be offered on CD-ROM, which is a popular device for computer-assisted learning. The specific role of the handbook, the CD-ROM and the website will be illustrated further in the following sections.

Handbook

The easiest way to read large pieces of text is still by using a book. It can be carried around and used independently of a computer. Personal notes can be made and keeping an overview is much easier using a book than reading through the small viewing pipe formed by a computer screen.

CD-ROM

The main tool for accessing educational material is a web browser. A browser is a navigation tool and a viewer for all kinds of multimedia information. It is standardized and available on all standard personal computers. It can even be used as a shell for running exercise and demonstration programs written in the Java computer language. The information source can be a website but may also be a local file or a CD-ROM. The CD-ROM will typically be used for large amounts of data that take too much time to transfer over the Internet or for data that cannot be distributed freely, such as licensed software or databases used in demonstrations and exercises. A disadvantage of CD-ROMs is that they require regular replacements or updates.

Website

In contrast to CD-ROMs, a website can be updated regularly. Errors can be corrected, new information added and temporary information can be replaced by updated information. Another advantage of a website is that it requires no other pre-installed programs other than a standard web browser. A website offers several ways of navigating around the information. The table of contents, the key word list or the glossary give access to the information just like the handbook, but also provide additional links to exercises, illustrations, examples and other websites (see Figure 1). The information is organized logically in chapters divided into sections and paragraphs, but this is only one view, that of the Handbook's editors. Information relevant to a topic, such as signal analysis, is distributed over several chapters. The website offers alternative ways to navigate through the information by selecting a topic or by using a graphical information browser.



Figure 1

The home page of the *Handbook of Medical Informatics* website (<http://www.mieur.nl/mihandbook>). Reproduced with permission from the Institute of Medical Informatics, Erasmus University, Rotterdam, The Netherlands.

Another reason for using a website is the possibility of interaction with the server. Exams can be generated on request and the server can keep track of the results.

Organizational structure

Setting up and maintaining a website requires co-operation between experts in the field from all over the world, and this in turn requires organization.

Co-ordinating centre

The Department of Medical Informatics at the Erasmus University in Rotterdam is the co-ordinating centre of the project. The co-ordinating centre is responsible for the development and programming of software and tools for the website, and for the adaptation and integration of third-party software, examples and illustrations. The co-ordinating centre maintains a database and a registry of all available information elements and takes care of internal consistency and cross-references. An important task is co-ordination of the information supplied by international experts.

Collaborating centres

Collaborating centres are selected by their expertise on specific topics and will deliver exercises, examples and illustrations, questions and answers or literature. For each information type, guidelines are prepared by the co-ordinating centre in the form of a protocol describing the format of delivery and the procedures to be followed for acceptance. For example, questions and answers can be delivered as free text with special tags or key words for the question text, the possible answers, comments and an explanation for each incorrect answer and possible links to

included pictures or videos. In this way collaborating centres can concentrate fully on the content and do not have to worry about converting it to hypertext mark-up language (HTML) format for the website. The co-ordinating centre is responsible for further processing.

Editorial board

Quality control, internal consistency and language are the main responsibility of the editorial board. All information will be offered in the English language only, but for specific parts, such as questions and answers, a translation into the student's native language may be provided. The editorial board consists of experts with a broad view of the field. In order to prevent impasses and to keep ideas innovating, the members of the editorial board rotate tri-annually.

Results

The website product consists of the teaching material on the website and the software developed for maintaining and building the web pages. The latter consists of a *database*, containing the entire contents and structure of the website, and *generator software*, which generates the web pages from the database.

Website

The website contains both material from the handbook and information supplied by collaborating centres. For readers of the handbook, the connection with the website is made easier by printing all links to glossary terms in the text in blue. A more direct coupling has been considered, but appeared to be too expensive. The main entry to the handbook is through the menu on the home page (see Figure 1). The following material from the book is available.

- Glossary: a list of key words with explanatory text derived from the handbook and expanded with new key words and descriptions. The glossary is ordered alphabetically for easy browsing and for saving downloading time. Initially a list of key words is presented, and clicking on a key word provides an introductory description. Most descriptions offer links to other relevant pieces of information such as figures and demonstrations, or to more elaborate text fragments. Where appropriate, links to other websites are provided. In this way, the glossary provides a systematic entry to topics described in the website.
- Tables: structured pieces of information like formulae and statistical data. A table may also contain links to other information.
- Panels: condensed pieces of theory or an explanation of a certain topic. A panel may contain links to further information.
- Parts of the text: selected sections of the book are made available on the website in addition to tables and panels. They are accessed from other material such as the glossary.
- Figures: all figures contained in the handbook are available on the website. Each figure is presented as a small 'thumbnail' version of the image, which can be clicked on to produce a larger version (600×380 pixels) that is

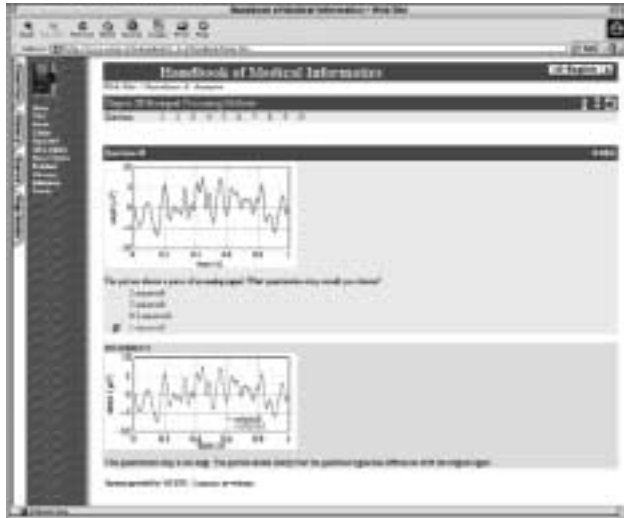


Figure 2

Example of a question from Chapter 25

Here a wrong answer has been selected. Feedback information is given at the bottom. Reproduced with permission from the Institute of Medical Informatics, Erasmus University, Rotterdam, The Netherlands.

presented with the caption. All figures from the handbook are indexed by a list of figures and are grouped per chapter. Other figures, such as those used by the question-and-answer sections cannot be accessed directly from the list of figures.

- **Meta-information:** information such as the addresses of authors and editors, references for advanced studies, how to use the handbook etc.

In addition, material in the form of questions and answers is available. These are multiple-choice-type questions and answers with explanatory text, which are provided for self-testing (see Figure 2). The questions are currently grouped by chapter. Each question consists of text with or without other multimedia information, such as a figure, a piece of video or a sound. The possible answers (from two to ten) are hyperlinked text fragments or thumbnail images. Clicking an answer changes the colour of that answer to green if it is correct or to red if it is not. Comment on the selected answer is shown below the answers listed. Such a comment can be simply “You selected the correct answer” or explanatory text. The explanations provide links to relevant pieces of information on the website, such as text from the book, panels, tables or even demonstrations or literature. In this way the student can quickly find background information relevant to the question. The majority of the questions in the current set of questions and answers are selected from old exams from the Department of Medical Informatics, Erasmus University. Each question supplied is first reviewed by the team at the co-ordinating centre and, when found to be syntactically and semantically correct, it is published on the website, but only for viewing by members of the editorial

board. After the editorial board's approval is obtained and the language corrector applied the question is published in the next release.

Database

The information content of the website is stored in a database, in a more general format than the HTML format required by the browser. This database is stored on a Windows 95 personal computer. It is needed to keep track of all the changes and links between all information items. The database also provides means for version control and is the basic information source from which most of the HTML pages are generated. Special editing tools facilitate changes to the information in the database. In the source data hyperlinks to other information items (figures, tables etc.) are specified with special tags followed by named references. A special tool checks the consistency and correctness of the cross-links. The editing tool determines which changes can be made and can check whether, for example, a deletion can be made safely. In this way the final website will be more consistent with less effort. Every type of information on the website can be stored in the database. The database is set up in such a way that all types of information can be linked and that new types can be added easily in the future.

Generator

There are a few existing programs that can generate HTML from databases or even entire websites. An example of such a program is Microsoft FrontPage 98. However, these do not offer enough flexibility for our purposes. Therefore, an in-house website generator was developed under Windows 95 with Borland (Inprise) Delphi 3. This generator is accompanied by other tools, for example a tool for the import and export of questions and answers, and a link-checker tool, which checks all links assigned to other data (e.g. from a glossary key word to a theory panel). The structure of the HTML pages is also stored in the database as HTML templates. These templates can be changed easily and avoid reprogramming of the generator software every time the layout of a HTML-type page changes. Each template consists of pieces of HTML code plus a number of special tags (marking points) that are used by the generator software and replaced by generated pieces of HTML from the database. Before generating the website a couple of parameters can be set (e.g. the version, or the parts that need to be generated). During generation the templates are filled in with data from the database and all links are transformed to hyperlink code. After generation the website is checked, transferred to the Internet server and made available for use.

Discussion

The combination of a paper handbook and a website can accommodate some of the needs of the handbook's users, as described in this chapter. The combination presented here is applied to the field of medical informatics, but this approach could be applied easily to other fields.

There are a number of considerations when designing a website. For instance, presenting a large amount of multimedia information on the web

automatically puts demands on the speed of the connection (bandwidth) between the user and web server. To accommodate users with a low-bandwidth connection, material should be presented in reasonably small quantities. Another point to take into account is that the user should be provided with a clear image of the site's structure. User-navigation tools (buttons etc.) should be consistent and intuitive.

In the future it must be decided upon whether or not combining a paper handbook with a website is useful for educational purposes. In our opinion, the current website meets this requirement only partially, due to the limited amount and type of additional material. Nevertheless, we decided to publish the website on the Internet before completion for two reasons: first of all a website like this will never be complete, since it is meant to contain material at the cutting edge of scientific research. That means it will have to be updated on a regular basis. Furthermore, receiving feedback from users (students as well as teachers) will influence future developments and ideas concerning the website's functions and structure. Our aim is that future versions of this website will contain more material, supplied by teachers and students from all over the world, but also material in different forms. The remainder of this discussion will therefore focus primarily on the future additions of the current setting.

Educational modules

The paper handbook is arranged into chapters, each dealing with a particular subject. Some subjects are distributed over several chapters, depending on their complexity and the quantity of information on them. Other subjects are discussed in one particular section, but are referenced throughout the book, where other aspects of the subject are treated. When a student wants to study such a subject thoroughly, he or she needs to look up all these different sections. One solution to avoiding this would be to allow the material be structured in several ways. Depending on the viewpoint of the student or teacher, all related material is presented together in a concise and intuitive format. This concept is referred to as *educational modules*. It allows different views on the same material, so that material scattered over different parts of the paper handbook is presented as one module. Such educational modules will consist of text and images, but also questions for testing comprehension.

Interaction

To be able to teach skills instead of knowledge, one has to use the acquired knowledge in situations where that knowledge is appropriate. In our setting this can be achieved by simulations and interactive exercises. An example of such an exercise is a program about signal analysis. The student must choose parameters that define the recording of various biological signals. Various processing techniques, such as filtering, can be applied to the signal. The resulting recorded signal is presented graphically together with the original signal. This illustrates the effect the chosen parameters have on the resulting signal. Such exercises can be far more educational than reading plain theory. Such simulations or exercises can be implemented in Java or JavaScript, allowing easy access via the Internet, or in

more conventional ways, such as a program that must be downloaded and installed before it can be used.

Multilingual material

Since the website is meant for an international public, we plan to offer some material in languages other than English. It is important, especially in education, to use the language that students can understand most easily. Collaborating centres are encouraged to provide material not only in English but also in their native language.

Testing

Testing is important, since it gives the student or teacher an impression of how well the material has been mastered. Frequent self-testing by the student can indicate areas in which more study is needed. Generating tests from a database of questions may be a useful tool for such self-assessment. Such tests may, unlike paper tests, include multimedia components. Adaptive tests are also possible, with questions not chosen before testing, but during testing: the next question depends on the answer given for the current one. The generator could, for instance, pick more difficult questions when the student appears to have a good understanding of the material based on the answers given to previous questions. The results are stored, so that next time the student takes a test questions can be chosen according to the study profile. Actual testing of students by a teacher is somewhat more difficult, since precautions must be taken to prevent fraud.

Presenting the student just with examples of medical-informatics applications might suggest that these kinds of development only take place in the field of medical informatics. To emphasize the broad field in which these developments take place the website will be expanded with demonstrations of computer applications in medicine.

To give the students a greater feeling of reality when working through the website, some of the underlying data appear as if they are taken from actual patients. This will give the students the feeling that the material is applicable in real-life situations. Students will be unmotivated when they have to perform a task that, according to them, lacks usefulness. As an example, an underlying database with patient records (made anonymous) could be used for questions and answers or exercises.

The possibilities of the Internet in the future are enormous, whether it relates to medical professionals who are performing their job or to those who are being trained. It is important to correctly present the possibilities of the Internet to medical students. Giving attention to the Internet makes the new generation of medical professionals aware of the current state of the art, and helps them make better use of the technology. It will not only help in providing and finding medical information, but also in providing new ways of communication. By letting students use the technology at an early stage they can experience the benefits and will be more open to accepting new developments in the future. All this will benefit healthcare in general.

But herein also lies a hidden danger. If medical students do not experience the potential benefits at an early stage, they will be reluctant to adopt it

in the future. That would be a pity, considering the possibilities for increasing both the efficiency and the quality of healthcare.

References

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