Web Browser Support for Problem-based Learning

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Abstract

This project was intended to develop the investigative competencies of undergraduate Biological Science students. It has developed a problem-solving approach to designing student practicals in Immunology, changing the learning process from being teacher-focussed to learner-focussed and providing students through situated learning with the necessary skills to make decisions about what they do in the laboratory. A suite of problems created can be solved by the students' development of their own laboratory protocols, using learning support materials generated during the project. The knowledge base consists of topic summaries, key references and detailed experimental protocols. A hypermedia version in HTML includes visuals of experimental outcomes and an image and audio glossary linked to the theory and experiments. The computer-based material produced in 1995 enhanced the use of paper resources on which the system was trialled in 1994 and broadened the scope and potential outcomes of the project to include use of the resources of the World Wide Web.

Keywords

immunology, problem-based learning, Web, contextual learning, hypermedia, HTML

1. Introduction

Teachers in disciplines that involve laboratory work have long been concerned at the tendency of their students to treat the lab manual as a recipe to be followed. This is only to be expected: students, if they succeed in following the steps, have little control over the situation and cannot feel seriously responsible for the outcomes. The current project began as an attempt to instil in students an understanding, and hence ownership, of their laboratory activities. The project recognises that knowledge is contextual, that responsibility is a motivator and that students benefit from opportunities to think about their own learning.

2. Project Beginnings

The original project was to develop a problem-solving approach to designing student practicals in Immunology, changing the learning process from being teacher-focussed to learner-focussed and providing students through situated learning with the necessary skills to make decisions about what they do in the laboratory. A suite of problems was to be created that could be solved by the students' development of their own laboratory protocols, based on reading of theory and research papers. This project was supported by a National Teaching Development Grant in 1994.

A review of the literature on problem solving indicated that, for effective solution, problems need to be structured to allow (a) conceptualisation of the problem and (b) relationship to key knowledge domains. Although considerable research has apparently been done on the processes involved in problem solving, little of it is particularly helpful in designing problems with a laboratory solution in mind.

The standard approach to problem solving has involved a practice-based model where students are presented with a problem and its solution. Students then develop their own skills in the light of this model answer. This process is quite understandable in mathematics and physics but defied transposition to this project. While the modelling of laboratory techniques by the instructor is necessary, the modelling of the internal problem-solving process is less accessible to view. The students are therefore put in the situation of solving problems themselves with supportive learning materials available.

The problems we needed to devise were concerned with developing the students' ability to think, plan, access information and evaluate laboratory protocols in the light of desired outcomes. Therefore problems need to be initially patterned on a simple directive such as: Design an experimental protocol to investigate ... etc. Initial problems would be capable of solution through access to straight forward analytical protocols, whilst higher order problems would require the marriage of a range of protocols and access to the research literature.

The problems are presented in a context which gives support to the learning process. To explore possible options in the solution of the problem (without costly laboratory-based activities) we have developed a database of laboratory procedures and their outcomes all related to the theoretical framework of immunology.

The arrangement of this support material makes use of the divisions used in the subject.

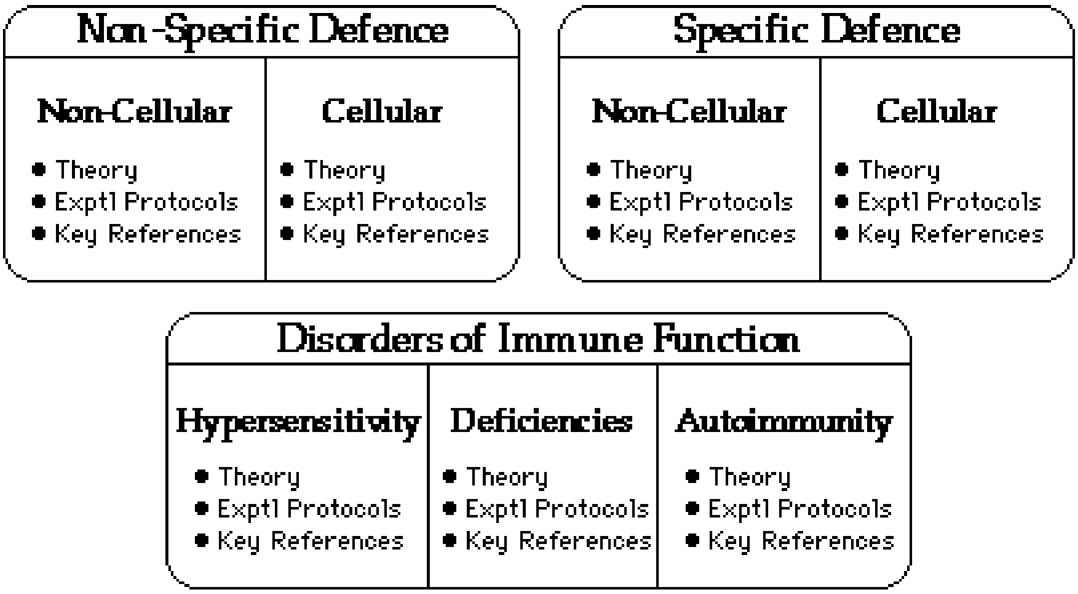


Figure 1. Theoretical divisions in the subject.

In using the project materials the student is intended to feel ownership of the learning process, arising from responsibility for the conceptualisation, design and implementation of laboratory experimentation.

In semester 1 of 1994 and 1995 the material was used on paper. Working in pairs, the 16/18 students used the resource base to develop a laboratory solution to two problems, one simple, one complex. Their solutions were shown to the lecturer three weeks prior to the scheduled two-day practical session and discussed. Students were required to organise appropriate equipment and laboratory consumables (within the boundaries of the protocols and others they may have accessed in the literature). At the end of the two-day prac, each pair gave a fifteen-minute presentation of their problems and solutions which they then wrote up as a paper.

The 1994 evaluations on a 5-point Likert scale using the University's standard Student Feedback Questionnaire are presented in table 1 and clearly show the students satisfaction with the learning process.

Topic	**Mean**
Overall learning	4.8
Own planning ability	4.1
Practical organisation	4.2
Effectiveness of practical work	4.3
Own development of practical skills	4.7
Understanding of subject	4.3
Skills developed	4.8

Table 1. Student responses.

3. Hypermedia

The learning support material has been implemented as a collection of linked hypermedia files written in HyperText Markup Language (HTML) as used on the World Wide Web. The hypermedia program produced is a support to the research process used by the students in solving their problems. It enables rapid random access to relevant textual explanations, an audio and image glossary and displays typical results of experimental procedures.

In choosing an authoring tool, consideration was given to the specific delivery situation, to the specific project requirements, to the current expertise available and to the general ability of the tool to implement an instructional design. In addition, the ease with which the product can be maintained and modified must be considered from the beginning. The details of these have been discussed by Pennell and Deane (1995).

Immunology is an active field. The product will fall into disuse if its knowledge base becomes dated and it is unable to be maintained and modified by the institution and staff supporting its use. The choice of authoring tool is critical in enabling such maintenance to be performed by available staff. The use of HTML allowed maintenance tasks to be devolved to the Faculty and broadened the scope and potential outcomes of the project to include use of the resources of the World Wide Web in the knowledge-base. Using the Web and HTML as opposed to a closed CAL authoring system also harnesses that fundamental of human motivation, selective attention and further situates the learning in the real world of networked information sources that will surround these students for much of their professional careers.

The material is organised to allow the solution of a graded series of problems, with theory, experiments and references organised as shown in figure 2. The arrows describe the unfolding of the structure of the knowledge base as the user moves outward from the problems.

Students enter the program through the problems; they can then select on the screen to investigate any of the major areas displayed above. This process allows them to explore experimental procedures and their outcomes, as video clips and still photographs are incorporated into the text.

The value of each experiment in investigating immune functioning can be clarified by cross-referencing to the text.

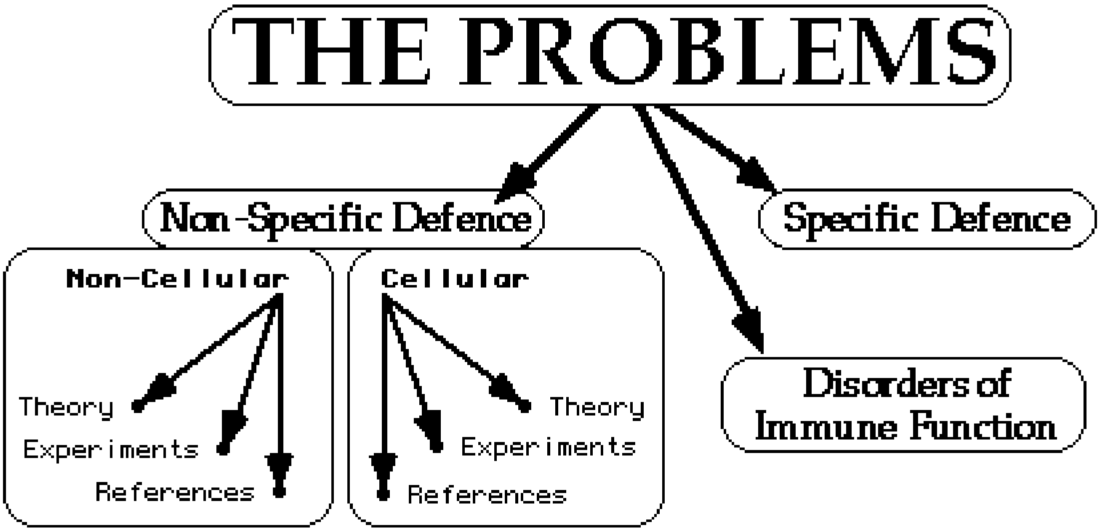


Figure 2. From the problems to the knowledge base.

Students are not 'spoon-fed' the solutions to the problems posed. There are no 'hot' keywords in the problems that will lead them straight to the experimental solution. They need to determine through their reading of the theory and references which experiments would be most informative for their current problem.

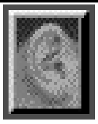
The various subsections of the knowledge base are hyperlinked within their own section, to the top level of the three major sections and to the problems and the glossary. The student is able to move rapidly back and forth between them. For clarity, only one of the three sections of the knowledge base has been expanded in this view and the links have been omitted.

The knowledge base includes text, images, sounds and digital video. The text includes current theory, descriptions of experiments and lists of relevant journal articles for reference to particular research areas. The sounds are pronunciations of terms described in the associated glossary. The images and digital video are used to show the results of experiments and to assist the explanations of the glossary.

HTML 'programs' are readable in and can be modified by any word processor. The language has few elements—add-ons to popular word-processors will soon make the creation of HTML mark-ups quite straightforward for any computer user. In our specific instance the single storage site and ease of modification of the material is valuable. The lists of references must be updated at least annually. They could in fact be updated by clerical staff on an almost daily basis.

Internet links are included to general Biochemistry references and in the glossary to sites relevant to specific terms as shown in figure 3.

These links can be regularly updated without difficulty to integrate current best practice and new protocols wherever they are identified. A Web search engine is linked into the courseware and used to supplement the sources identified by students in their assigned research tasks. (The listings of reference articles used in the learning support material have already been augmented by additional sources used by students in 1994 and 1995.)

MHC (major **histocompatibility** complex) 
A genetic region found in all mammals whose products are primarily responsible for the rapid rejection of grafts between individuals, and function in signalling between **lymphocytes**< and cells expressing **antigen**.

See also **the MHC Web site**

Figure 3. Glossary entry. Bold words are links; the button triggers pronunciation.

4. Problem-based Learning

The PBL tutorial process was developed by medical faculty at McMaster Medical School in Canada from 1969 and its varieties have been documented by Barrows (1986).

Steve Waldhalm (1995) of the College of Veterinary Medicine at Mississippi State University describes problem-based learning as an educational strategy designed to:

- maximize active student participation in the learning process,
- foster student problem solving and self-education skills,
- enhance student self-assessment,
- increase student communication skills,
- improve student abilities to access and utilize information resources.

> Problem-based learning involves the use of clinical problems (or cases) to create an active, student-centered learning environment. Each problem stimulates small group discussion and student research of the basic and clinical sciences relevant to that problem. Since most (if not all) problems require an interdisciplinary approach, students learn the various basic and clinical sciences in an integrated fashion.

There are clear parallels in intention between PBL and the approach we have adopted in our Immunology project. In this ‘traditional’ PBL approach, however, students in groups of about five per tutor work through prepared case studies with layers of information of increasing complexity revealed during a series of meetings. Through the tutorial discussions students find the gaps in their personal and group knowledge and develop their own learning tasks to redress these. They are responsible for framing and for assessing their achievement of them. Our approach with a larger groups is clearly less structured, lacking the iterative revelations and formal meetings, and is intended only for students at an advanced stage of their course.

PBL is used at very many tertiary institutions at all stages of teaching and there is even an annual PBL conference in Australia. Grahame Feletti (1993) has assessed the development of the method and described a similar approach used at the University of Hawaii which is referred to as Inquiry Based Learning. He sees the various types of PBL as ‘promoting Interesting, Interactive, Integrated and Independent learning’ and writes that there is no simple recipe.

The BioQUEST Curriculum Consortium (1995) in the USA has similar aims to the supporters of PBL:

foster an understanding of how biologists perceive the world; Pose questions; pursue Problems from those questions; and ultimately, Persuade others of the value of their conclusions.

This organisation promotes and distributes computer-based material which acts as the focus for teaching using the 3P learning environment, teaching science as an active investigatory process.

Ralph Bloch (1995) at the University of Berne has proposed an alliance of those using the World Wide Web for PBL, stressing the natural fit between the character of PBL and the distributed hypermedia of the Web, extensively documenting the educational and technical considerations that apply.

5. Current Developments

In the Problems in Immunology Web project there are currently approximately

- 20 problems grouped in two levels of difficulty;
- 130 A4 pages of knowledge base, experimental procedures and references;
- 35 HTML files of ~10kb;
- 150 image (gif) files of ~10kb; and
- 100 sound (aiff) files of ~15kb.

The total disk space used by these files is approximately 3 megabytes.

The structure implemented is largely as described above, with the addition of a simple support file dealing with the Netscape interface and an overview file to establish the landmarks of the knowledge space.

The system has been used on standalone Macintosh computers (Centris 650, LCIII and Quadra 610) and on an Ethernet LAN over AppleShare. No technical difficulties were encountered. In the case of the LAN, the browser software was located on each machine, the data files and Home Page on the server. This single storage is a feature of client server systems and the Web. It will potentially allow users at other institutions to make use of the material without a local installation.

The speed of response is adequate but by no means as rapid as courseware produced in a conventional authoring system.

This use of Web browser software as a standalone multimedia presentation engine avoids the need for maintenance of a Web server but removes some of the interactive abilities of the Web (diagrams with hotspots require CGI (Common Gateway Interface) scripting on a Web server).

The limited interactivity of the Web browser compared to a conventional CBL tool such as Authorware or Toolbook has not been of major disadvantage so far, but we would like to illustrate some concepts in the learning support material by making use of existing CBL items. The available mime types do not satisfy the need and experiments with local types have not given consistent results. HyperCard can be launched satisfactorily but stops at the Home stack, not loading the lesson stack. Early versions of Authorware perform well but current version behaves similarly to HyperCard. We will be keeping a close watch on ongoing developments of Netscape and HTML standards.

In the audio glossary the lecturer's own voice was used, ensuring acceptable pronunciation. The sounds were to be stored as 8 kHz .au files in accordance with Web practice and the need for minimum size. The downsampling of the female voice, however, introduced unacceptable distortion in some terms. Initially a male voice was substituted for these but later the original source was resampled to 11kHz .aif files and a different helper application used. The pronunciations are now much more useful to students, although there is increased storage and transfer load.

Problems associated with the creation and use of a glossary have been discussed by Gotts and Makray (1993). They identified access speed as a critical factor in encouraging student use. The glossary material has been broken into four files in order to reduce the initialisation time. There is a separate but acceptable processing time as the .aif file and the helper application are loaded following the student's click on an audio button.

From the inception of the project the evolving nature of the reference material in Immunology was seen as the source of a considerable maintenance problem. The use of HTML has reduced the difficulty of maintenance and the rapid growth of Web resources has allowed the incorporation of dynamic and updateable links to external information sources. This valuable capability has greatly expanded the search space for students and will allow them to use the project to gain experience as operatives in the developing global Science community.

6. The Future

The Web and Web browser software are appropriate tools to introduce hypermedia support to the existing processes of learning laboratory competencies. HTML material is easily used, distributed and maintained. The availability of cross-platform implementations of the common Web browsers will greatly broaden the application of this and similar learning support material.

Many academics are rushing to display their teaching material on the Web, but the generally one-way flow of information that is in the nature of the Web carries with it the potential for breeding 'Web potatoes' to replace the couch potatoes of the TV generation. We fear the creation of a host of page-turning applications, similar to the experience of amateur computer-based learning materials. Perhaps the use of a combination of PBL and Web delivery will allow educators to realise the promise of the Web while maintaining 'Interesting, Interactive, Integrated and Independent learning'.

7. References

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