World Wide Web Publishing as a Basis for Student Projects[1]

PAPER

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Students were set the task of publishing a set of pages on the World Wide Web to explain a chemical concept in detail. This was run as a ten week final year undergraduate project. The pages were written in simple Hypertext Markup Language, and students were encouraged to search for their own sources of material and to discover the best forms of presentation. The projects are consequently truly open ended, and require a much more structured approach than would a traditional dissertation. Web publishing is a valuable skill which will be of increasing interest to potential employers.

Introduction

Many scientists, and others, are currently interested in exploiting the potential offered by the World Wide Web (WWW)[2] as a means of disseminating material on a whole range of topics. In addition to conventional publications[3,4] meetings have taken place[5-6] to allow 'webmasters' to discuss the latest developments in this technology. The nature of chemistry is such that several specialised tools[7] have been developed in order to facilitate use of the WWW in this area. This may give the impression that in addition to needing specialised resources one has to be an expert in order to produce material for display. While this is true for web pages which include sophisticated features such as animations, more basic but satisfactory results can nevertheless be achieved with relatively simple techniques.

One such simple technique involves the use of hypertext. This is a well known concept,[8] and a number of specialised computer programs for producing hypertext documents have been available for some time. Essentially, certain items of text are designated as links to more detailed material, and a user can navigate backwards and forwards through these links at will. The term hypermedia is sometimes used to describe the extension of hypertext to include images. The WWW extends this concept by allowing the links to refer to other documents elsewhere on the web (i.e. on remote computers), whereas in simple hypertext they would only refer to other local material.

One reason for subsequently choosing tools developed for WWW document production to develop such documents using relatively simple hypertext was their ease of use, and consequent suitability for teaching to students. Relatively few commands need to be known before readable pages can be produced. Most of the software required is available free of charge for educational use, and the computer hardware requirements are quite modest. These considerations suggested the possibility of undergraduate projects which would be intellectually demanding, open ended and chemically relevant, and which would lead to the development of skills and expertise likely to be useful to some students. Such projects could meet the exacting standards required of final year research projects, and could provide a welcome broadening of the conventional range of topics.

Two projects of this type have been run to date. The first contains material on the industrial production of urea, the second on the more general topic of crystallography.

Educational Objectives

As in most undergraduate chemistry courses, students in the chemistry department at the University of Keele undertake project work rather than following scripted laboratory experiments in their final year. As far as possible, students choose their project from a number supplied by staff; choice is ensured by offering about 4 projects for every 3 required. Students may undertake two ten week projects or one twenty week project. Project work is carried out during four-hour sessions timetabled twice per week. There is a potential difficulty with projects which do not require laboratory work in that students may work additional hours without supervision as there are not the same safety concerns as for laboratory based projects. However, staff are expected to uphold the departmental policy of restricting project work to these hours as far as is practicable. Projects are set each year in the area of computational chemistry, but I was interested in broadening the scope of these to include some for which the outcomes were more likely to be of interest in chemical education than in chemical research.

The overall objective of the projects is described in a paragraph taken from the descriptions on which the students based their choice of project:

"The skills to be taught in this project include the planning and design of educational material, the use of an authoring tool, searching of information sources, and evaluation of the product at various stages. No prior experience of computational methods is required, as the authoring packages do not assume any previous experience. The extent to which the software is developed will depend on the length of project selected (i.e. 10 weeks or 20 weeks), but the shorter time should still be sufficient to allow the basic framework to be established."

As these projects are a part of the practical requirement they must allow the development of some practical skills over and above those of information retrieval which are required for a literature survey. They do this in several ways. First the construction of hypertext links places a more rigorous demand on logical presentation than does the preparation of a written document. There is also a need to produce a meaningful and

aesthetically pleasing screen layout, and to consider the human-computer interaction. Furthermore the skills of using the relevant authoring tools in the production of WWW material are likely to be increasingly recognised as a skill which (at least some) potential employers may regard as being as valuable as the mastery of any single laboratory procedure.

Initially, one project on the industrial production of urea was offered to students. In view of the demand for this, two students were allocated by the Course Leader who asked to be provided with a second similar project. The subject for this was the broad area of crystallography. Projects are allocated to students by the Course Leader in order to maximise student choice. The student working on the crystallography project was reading dual honours in chemistry and computer science, and consequently had more experience and prior skill in this area than did his colleague.

Part of the brief for both projects was that they should produce material which would be of interest in the wider community, and the expectation was that they would be mounted on the WWW server when completed.

Methodology

The students were briefed to produce pages in Hypertext Markup Language (HTML)[9] using a simple text editor. The relatively small subset of commands summarised in Table 1 were used as the basis of the work. Students had free access to a scanner for the incorporation of photographic images and to Windows Paintbrush for the preparation of line drawings. The pages were viewed using the WWW browsers Mosaic or Netscape, depending on their availability on a particular computer.

Various hardware was used, depending on the availability of computers. The minimum platform was an IBM PC compatible 386SX with 2 Mb of memory and a 40 Mb hard disk. During the development stages it is not necessary to use a computer linked to the Internet; this is only required once the pages are more generally available on the WWW server.

A key reference[10] on the industrial production of urea was provided as a starting point for the student working on the urea project. The topic is not covered in the undergraduate course, and it provided an opportunity to introduce some industrially relevant material. The student concerned took advantage of this and made direct contact with industrial companies to obtain up to date information. The crystallography project was so potentially broad that selection of relevant material by the student formed an important stage of the work.

Table 1: Minimum set of Hypertext Markup Language (HTML) Commands

Command	*Description*
<P>,</P>	Beginning and end of paragraph
<B>,</B>	Beginning and end of bold text
<Hn>,</Hn>	Beginning and end of header text (1 - n - 6)
<UL>,</UL>	Beginning and end of unnumbered list
<LI>	Item in list
<HTML>,</HTML>	Beginning and end of HTML document
<HEAD>,</HEAD>	Beginning and end of undisplayed document header
<BODY>,</BODY>	Beginning and end of displayed document body
<ADDRESS>,</ADDRESS>	Beginning and end of address of author
<A HREF="f1.html">,</A>	Beginning and end of hypertext link to document f1.html
<IMG SRC="f2.gif">	Display f2.gif as inline graphics image

Results

The results of both projects may be viewed on the WWW.[11] A summary of the topics covered in the projects are given in Tables 2 and 3 respectively; no attempt is made here to show the relationships between each page since this can be quite complex with links forward backward and sideways. The crystallography pages introduce some additional features to the simple HTML commands listed in Table 1. Navigational

Table 2: Topics Covered in the Urea Project

Industrial production of urea†
The reactants
In the reactor
Formation of carbamate
Conversion of carbamate to urea
Effect of temperature on the conversion of carbamate†
Effect of pressure on the conversion of carbamate to urea†
Effect of excess components on the yield of urea†
A representation of the structure of urea†
Simplified flow diagram of the production of urea†
The recovery of unreacted reactants
"Once-through" type process†
Aminoethanol
Removal of urea
The formation of biuret†
The effect of temperature on the formation of biuret†
The effect of water on the formation of biuret†
The effect of atmosphere on the formation of urea†
How is urea sold in the UK?
The Kemira urea production plant, Rozemburg, Holland†
The port at Seaham†

† denotes a page which includes graphics

aids and icons give the user a far greater degree of flexibility in moving around. External links are included to other sites on the WWW, including the WWW Virtual Library Crystallography Site in Switzerland, as well as local links within a page. Commands are used to give greater control over the alignment of images, and to set the appearance of the background.

Figure 1 shows a typical page produced as part of the urea project, and Figure 2 the external links page of the crystallography project. Note the extensive use of icons in the latter.

Table 3: Topics Covered in the Crystallography Project

Introduction
Contents
Other sites for you to visit
An introduction to crystals
The unit cell
The seven crystal classes
Atomic coordinates
Lattices
Bravais lattices
Miller indices
Symmetry
Types of crystals
X-ray diffraction

Figure 1: Sample page for the urea project, showing hypertext links to other pages

Figure 2: The external links page from the crystallography project

Assessment of Effectiveness

The fact that the initial project was oversubscribed demonstrates the potential demand for this type of project.

Both projects were successfully completed in that they produced WWW pages which could be successfully viewed using an appropriate browser. The final products were enthusiastically received by the members of staff who carried out the oral examinations of the projects. Both students involved had become proficient in writing HTML code. A different measure of success was obtained by monitoring the access statistics for any file on the WWW server.These show that the urea pages are accessed rather more frequently than the crystallography pages, and that the former are the most frequently visited pages on our departmental site. In a typical week around thirty accesses of the urea home page take place.

The formal assessment of the student's project work followed the procedures used for all projects. Unfortunately this did not involve direct viewing of the material; this does not fit into the assessment strategy used for other forms of project. Each student produces a written report which is assessed by the project supervisor and a second marker.The project supervisor also provides an assessment of performance during the project. Since the two projects described here took place in different semesters, the third element of assessment differed. The student undertaking the urea project gave a talk to staff and fellow students, while the student who completed the crystallography project was given an oral examination involving two members of staff.Both students performed well in all areas of assessment of these projects, which made a positive contribution to their overall degree results.

Transportability

As noted above, production of such resources requires very little cost apart from the provision of a computer. Even this can be eliminated by using a text browser on a central machine, but then the advantage of including graphics is lost.

The topics for such projects need to be chosen with care. The two described here were quite different, with one being covered in many undergraduate textbooks and the other one not appearing at all. For a future project the ideal subject might be one which is touched upon briefly at undergraduate level, but which requires a reasonable amount of subsequent searching of literature and other information sources. Further work in this area will involve production of a resource to accompany an undergraduate chemistry module. The starting point for this will be the current printed module outline, and the aim will be to have a coherent set of pages comprising both links to external material of relevance and material written locally.

The advantage of this type of project is that students are often able to develop their skills quickly, and can therefore concentrate on scientific and creative aspects. They are truly open ended, being limited only by students' imagination. On the other hand, it may be difficult to monitor students who are highly computer literate, and access to suitable computing equipment needs to be ensured.

Acknowledgment

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References

1. A preliminary report of this work appeared as Yates PC 1996 Computer assisted learning using World Wide Web tools, in *Proceedings Variety in Chemistry Teaching* 1996, (Royal Society of Chemistry), p.21
2. Sangster A 1995 World Wide Web - what can it do for education? *Active Learning* **2** 3-8
3. Winter M, Rzepa H and Whitaker BJ 1994 Chemical applications of the World-Wide-Web system *J Chem Soc Chem Comm* 1907-1910
4. Winter M, Rzepa H and Whitaker BJ 1995 Surfing the chemical net *Chem Brit* **31** 685-689
5. Goodman JM 1996 Webmasters II http://www.lists.ic.ac.uk/hypermail/chemweb/9606/0021.html
6. Allen B 1997 register now for Chemistry Webmasters 3 http://www.lists.ic.ac.uk/hypermail/chemweb/9706/0018.html
7. Rees P 1996 Making the most of the World Wide Web *Scientific Computing World* **22** 23-28
8. Hardman L 1990 Introduction to hypertext and hypermedia *The CTISS File* **9** 2-6
9. Berners-Lee T and Connolly D 1995 Hypertext markup language - 2.0 - table of contents http://www.w3.org/pub/WWW/MarkUp/html-spec/html-spec_toc.html
10. Clausen CA and Mattson G 1978 *Principles of Industrial Chemistry* (Wiley, New York) pp. 363-403
11. Yates PC 1997 Keele chemistry resources http://www.keele.ac.uk/depts/ch/resources/list.html