UNIVERSITY OF PLYMOUTH

Science Education Enhancement and Development

SEED

Working Paper Series

CAL for Basic Science

Neil Witt, Tim O'Hare and Dave Harwood, February 1999

The SEED Programme, Faculty of Science, University of Plymouth.
Supported by the Higher Education Funding Council for England, through the Fund for the Development of Teaching and Learning.

AN INTRODUCTION TO SEED

The programme for Science Education Enhancement and Development ('SEED') is based in the Faculty of Science at the University of Plymouth. It is resourced principally by the Higher Education Funding Council for England through its Fund for the Development of Teaching and Learning. Additional support has been received from many areas of the University and particularly from Academic and Information Services. SEED builds on the success of the University of Plymouth Science Faculty in the national Teaching Quality Assessment system where Plymouth achieved 'excellence' in Environmental Science, Geography, Geology and Oceanography.

SEED's overall aim is to develop, document and disseminate good practice in Science teaching and learning. The programme consists of a series of projects in areas such as lab-work, field-work, graduate teaching assistants and computer-aided learning, which are itemised inside the back cover. Most are based in the Science Faculty but some have been taken forward by staff in the University's School of Computing and in Educational Development Services (EDS). All the projects are linked to dissemination partners in other institutions who act as external advisors, ensure that SEED's outputs are capable of being used in other institutions and help to disseminate and embed SEED's end-products.

Anyone wanting further details on the SEED programme is welcome to contact Brian Chalkley or Andy Elmes at the address below. Contact details for the individual project leaders are available inside the back cover.

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PAPER SIX

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Abstract

Student intake into science subjects at the University of Plymouth is extremely broad. Some entrants have appropriate 'A' levels, but most are weak or lack understanding in at least one key area (e.g. physics/chemistry). The support package defined in this paper provides a flexible source of basic scientific material relevant to the science degree programmes offered in the faculty and beyond via the wide-ranging and user friendly features of the Internet and associated interfaces.

General principles of the design of computer-based (in particular Internet-based) materials and learning packages are discussed with emphasis on the form of the learning process and the specific needs of the users (both staff and students). A number of tools for presenting material are described, and particular attention is given to methods of providing assessment and feedback. Examples of these aspects of the package, are illustrated with the delivery system. Given the developing nature of the package the scientific content is not discussed although examples of the type of material are shown for illustrative purposes.

Introduction

Recent advances in communication technology have allowed easy access to the Internet. This has fuelled interest in, demand for and research into methods of using and enhancing the technology to deliver education, training and continuing professional development. The availability, increased use, and acceptance of the Internet combined with increasing pressures on staff and resources[1,2], and the demand for multi-mode delivery, has necessitated a detailed investigation into new learning strategies for electronically supported distance learning[3].

Previous experiences of Computer Based Learning (CBL) and Computer Aided Learning (CAL) have resulted in a fragmented approach at both Faculty and Institutional levels and have been replicated across a large number of Higher Education establishments in the UK[4,5]. These unsatisfying experiences for both students and staff have resulted in negative attitudes that have to be overcome before electronic supported learning can be fully integrated into a modern curriculum[6]. A vital requirement for this learning strategy has been the development of a Faculty approach to electronically supported distance learning. This work is timely as the University is currently developing a wider portfolio of learning activities as part of its Student Centred Learning initiative.

The University of Plymouth has a "commitment towards becoming a truly accessible University - a University without walls."[7] This commitment has resulted in a number of initiatives based on a Telematic approach including this project as part of the SEED initiative[8].

The Faculty of Science is located on the Plymouth campus and specialises in Biological Sciences, Chemistry, Environmental Sciences, European Studies, Geographical Sciences, Geological Sciences and Marine Studies. The academic background of students studying science subjects is extremely broad. Some entrants have appropriate 'A' levels, but experience has shown that many have great difficulty in grasping the concepts required to understand at least one key area (e.g. Physics/Chemistry). Support for students with this difficulty has traditionally been via small group tutorials or guided personal study, both of which demand staff involvement. The basis of this project is to develop an alternative form of support for student learning.

This project aims to develop Internet-based open learning material which will provide students with the knowledge and information necessary to understand fundamental scientific principles. Faculty staff, in the light of locally and nationally recognised needs, defined the most common areas of student weakness, chiefly in the subject areas of chemistry and physics. It is envisaged that the initial framework and the associated tools will be made available to other staff within the institution. This will allow the website to become the host to a range of material. It is planned to provide a flexible source of basic scientific material relevant to science degrees across the Faculty and to utilise the wide ranging and user friendly features of the Internet and associated interfaces[9].

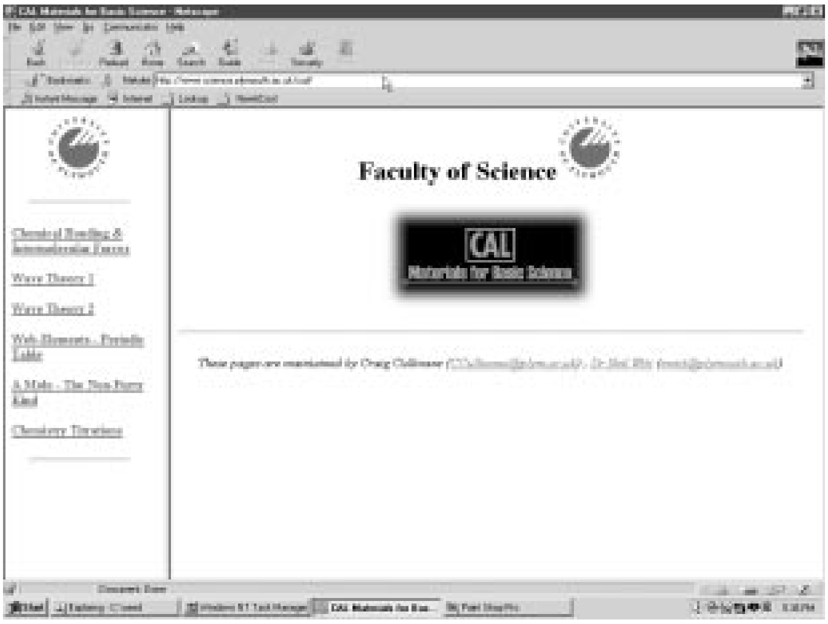
This paper details the function of the resultant courseware and investigates, the design process of the material including the definition of learner needs and the need for providing a user focus. Learner interaction with the web site content and information is investigated as are pedogogic principles, assessment and feedback structures. The paper is illustrated with examples from the project to show the key principles in the work.

The CAL for Basic Science Project

This project has provided a range of material covering different subject areas using material from a number of information providers. This has resulted in the formulation of different learning packages, each designed to meet a particular need within a department or subject area. The learning packages are designed for use by students in a wide variety of disciplines. The project has considered the needs of the students (the learner) and the staff member or tutor (the information provider). The learners and the information providers are both considered to be users of the system.

This approach differs from mainstream tutorial web sites such as ChemWeb[10] and the Physics Education Network[11]. These sites concentrate on providing the learner with the whole picture as a series of linked tutorials and resources. The CAL for Basic Science is intended to act as a host which behaves in a reactive manner, providing the information provider with a home and structure for their material and the learner the material to meet their needs. This is illustrated in Figure 1, the home page of CAL for Basic Science.

Figure 1. The CAL for Basic Science home page



Design of Materials and Learning Packages

The hypertext mark-up language (HTML) format of Web documents provides a relatively straight-forward authoring language to create hypermedia material. Using HTML as an effective solution requires planning in order to match the HTML output to the intended goal[12]. For example, a module web page is a convenient means to deliver copies of lecture notes and support material to students for their use before, during and of course after a lecture. However, the outline nature of lecture notes is of limited value to a student trying to learn about a given topic from scratch.

Graphical representations are not necessary to deliver textual information such as coursework deadline dates and only slow down the transfer of information which may frustrate the user. It is therefore necessary to choose the graphical content carefully.

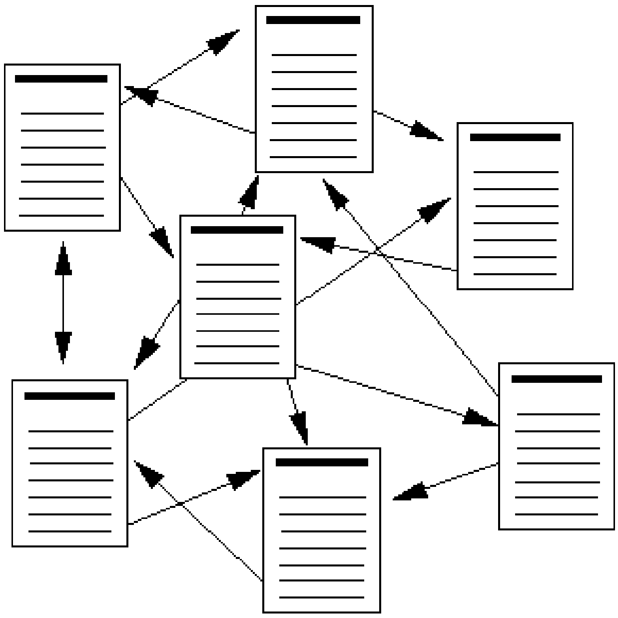
It is essential that the needs of the user (both learner and information provider) are the driving force behind a Web based delivery system. Hence, the material, interfaces and assessment structures are tailored to these user requirements.

The choices available to the information provider are wide-ranging. An HTML application is a collection of documents or pages that contain highlighted words or phrases called anchors, these form hyperlinks[13]. Hyperlinks lead the learner to other pages or other sections of the same page[14]. Hypermedia includes other media forms such as graphics, audio, and video. Links in hypermedia allow random access to information, and using a hypermedia application is usually referred to as navigating, browsing or surfing [15,16].

A learner can click on a link and go to a new document, browse it, and return to the original document. Alternatively a learner can click on another link and proceed along a different path to more information.

It is the learner who actively decides on the path through the information and in what depth to read each document. Random access and user control are major distinctions between HTML applications and conventional textbooks which are usually designed to be read sequentially from start to finish. If the learner is using printed material s/he can assume that the text will progress from simple concepts and examples to subject matter which may be considered to be more difficult or complex. The random access capability of HTML is illustrated in Figure 2. This shows a possible disadvantage of a perceived lack of structure which could confuse the learner by mixing documents of different levels of conceptual difficulty. In the case of a poorly designed site with limited navigational information it is possible for the learner to become lost in hyperspace.

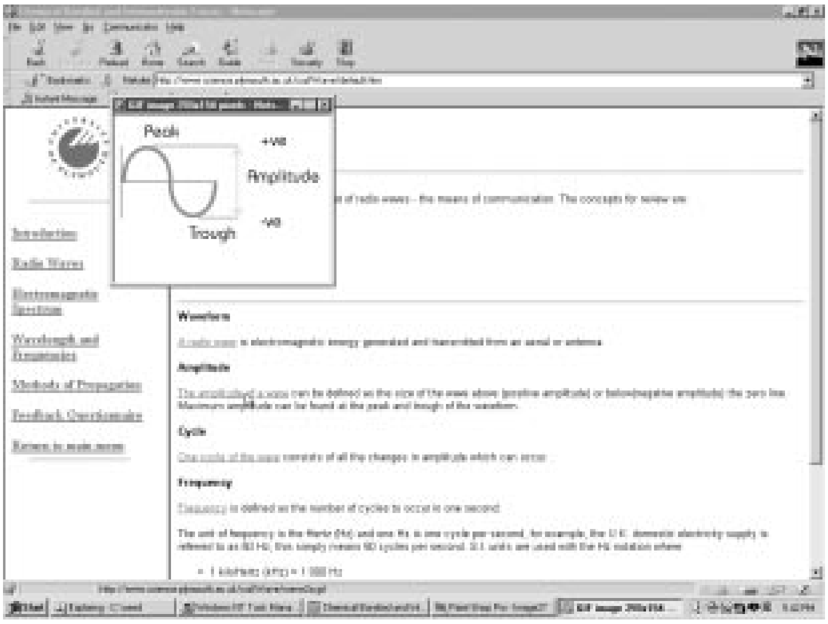
Figure 2. Example of unstructured HTML



An unstructured document layout may leave learners wondering if everything has been found. The project team investigated this area of concern and have developed a solution by putting up hyperlink barriers in the way of the learner as s/he clicks on links to access more material. This approach is illustrated in Figure 3.

The learner positions the cursor over the link. This ‘mouseover’ opens a new window displaying extra information such as text or graphics. The learner can then decide to follow the link or not. When the learner moves the mouse again, the new window will close.

Figure 3. Illustration of a mouseover to obtain further information



An alternative is to design an application with linear or indexed layouts, as shown in Figures 4 and 5.

Figure 4. Example of linear HTML

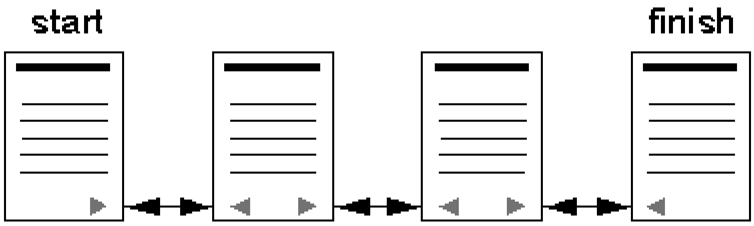
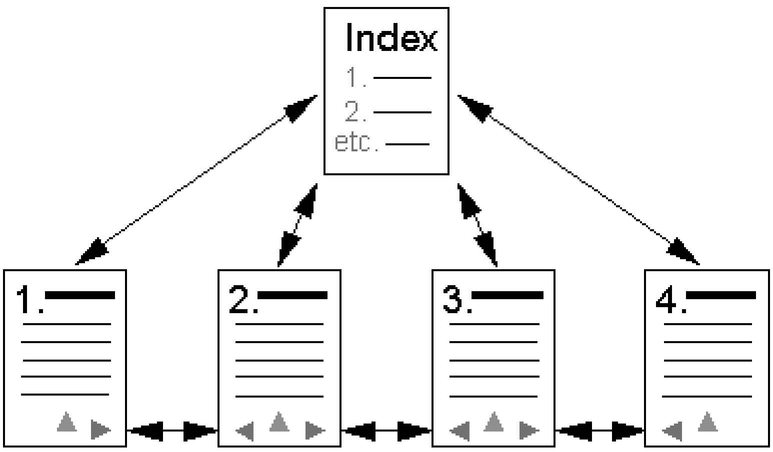


Figure 5. Example of indexed HTML

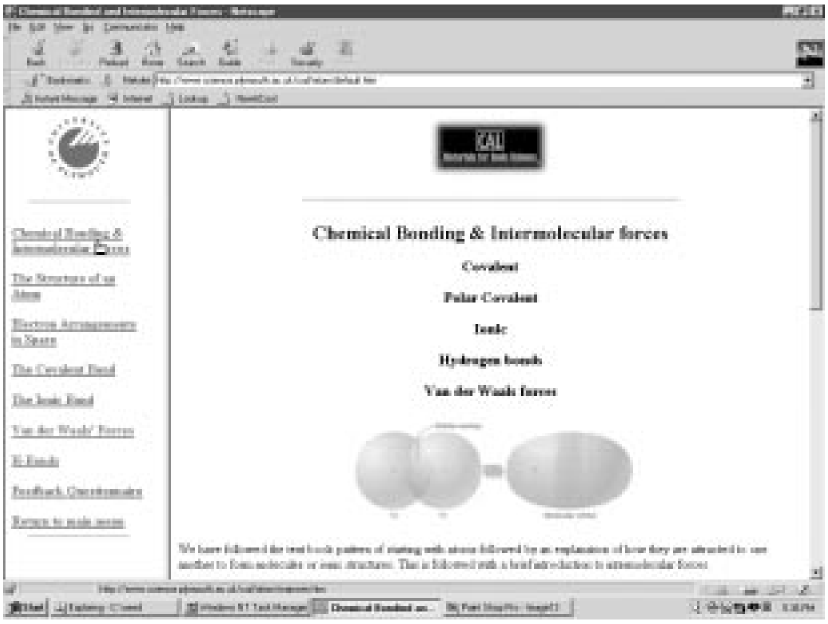


The arrows at the bottom of the pages in Figures 4 and 5 represent navigation aids that link to other documents. These can help learners retain a sense of direction as they work through a series of documents. Common navigation aids are text anchors that link to the “previous” or the “next” document in a linear series of pages, or to an index or home page.

For an HTML application containing a fairly small number of web pages, a complete sub-site map can be provided. Icons of left, right, or upward pointing arrows are commonly used as navigation aids to indicate a direction or home page. Non-intuitive icons (those that are not instantly recognised as having a specific function) that link to a home or index page should be avoided because they assume the learner has started from a beginning page and read instructions on the meaning of the special icon.

The two designs shown in Figures 4 and 5 provide a structure for learning material but lose the in-context access to related material that hyperlinks provide. A compromise is to use a hybrid design with a top-level linear or indexed structure and include hyperlinks in the text of the documents where appropriate. This can best be achieved by the application of frames and has been employed by the project team as illustrated in Figure 6.

Figure 6. Example of frames for learning packages



The index in the left hand frame allows the learner to select material, recap on material and extricate themselves from any dead ends or repetition of material.

The learner is then able to follow the sequence of material in a way that seems most appropriate to their needs. In the case of the material in Figure 6, the learner can read down the page until reaching further information regarding issues on covalent bonding, illustrated in Figure 7. Clicking on this link accesses further information on covalent bonds (Figure 8). The next link takes the learner to the periodic table where further information regarding the elements can be obtained.

Figure 7. Sample of learning material: chemical bonding

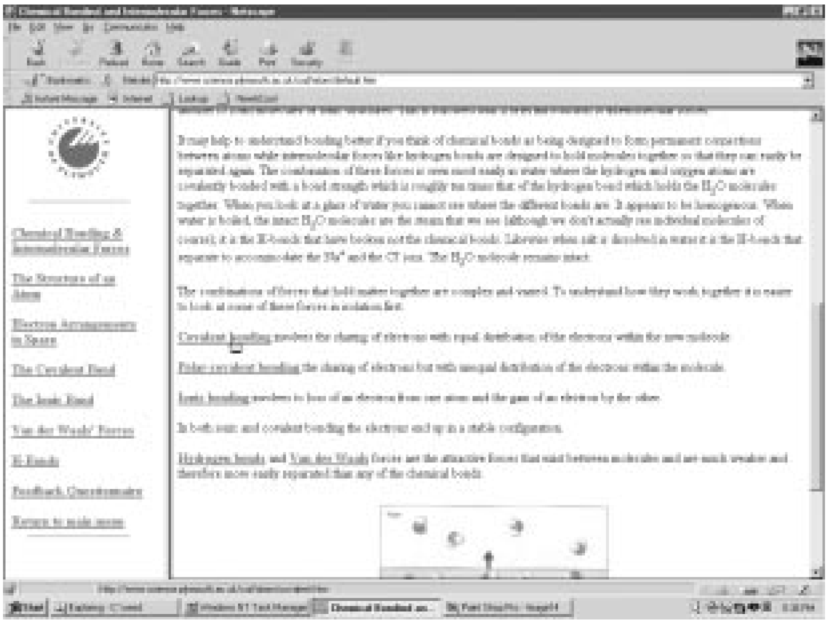


Figure 8. Sample of learning material: the covalent bond

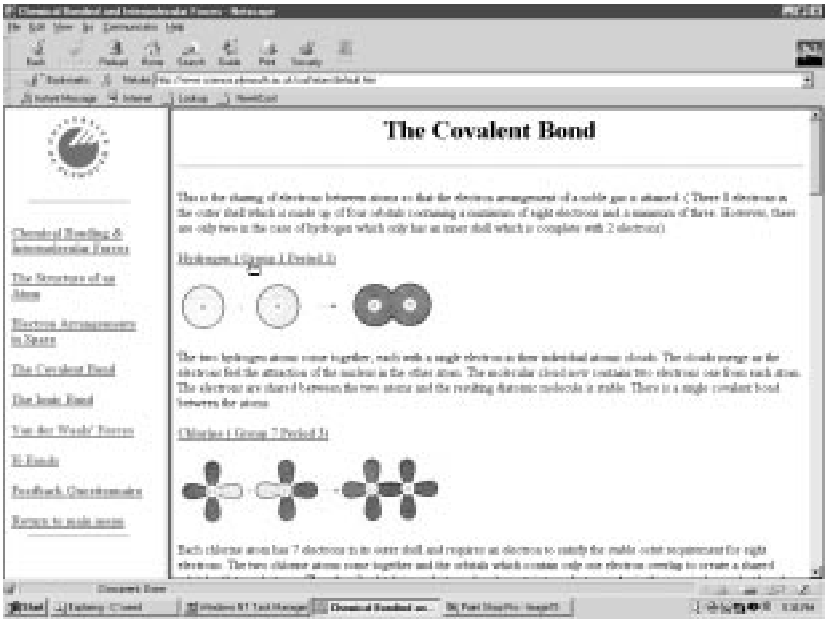
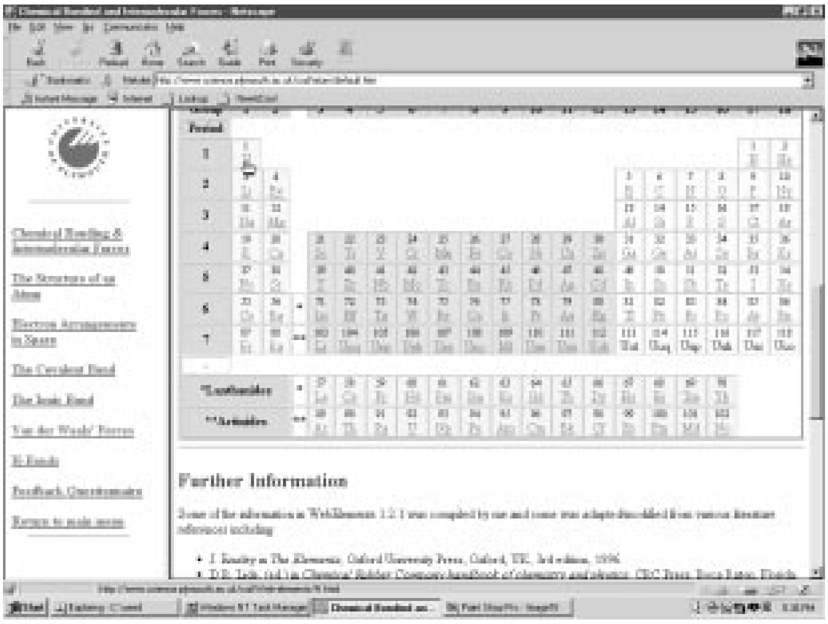


Figure 9. Sample of learning material: the Periodic Table



Access to an electronic periodic table was felt to be paramount for this work. The project team investigated possible sources for this and were able to secure use of the WebElements Periodic Table for no charge[17].

Utilising third party information provides the learners with a valuable resource whilst allowing the project team to concentrate on the preparation of materials and other resources.

Definition of Learner Needs

With the needs of the learner as the driving force of this initiative, it is essential that the experience offers consistency between materials in terms of layout, ease of use and quality.

It is essential that learning packages be:

- Functional: learning packages should be designed to allow ease-of-use and should be fit for purpose. All material must have defined learning outcomes and:
  - use graphics and media to support learning with particular attention to bandwidth limitations and download time;
  - organise linked files in a manner supportive of the purpose and learning outcomes of the course or module;
  - be updated and maintained as required.

- Organic: learning packages should be optimally integrated into the Internet and should:
  - optimise the use of hypertext links to related pages;
  - feature maximum interactivity;
  - be capable of continuous development in a straightforward manner.

- Technologically Appropriate: learning packages should aim to incorporate technological features which
  - ❖ enhance the value of the learning package by:
  - ❖ providing graphics in appropriate format;
  - ❖ using media as appropriate to enhance learning;
  - ❖ periodically receiving technological upgrades from central provision to match technological enhancements available to users.

- Educationally Meaningful: learning packages should, in their graphic appearance and interactivity, communicate an open, accessible, and meaningful engagement with the content. Interactivity should facilitate engagement with the material, including, when possible:
  - ❖ immediate feedback opportunities;
  - ❖ responding to surveys and questionnaire;

Maintaining a user focus

The learning packages should be designed with the needs, desires, and differences of learners in mind. Defining the target audience for a learning package and defining the key characteristics of that user population, are important steps in the design of the system. Once this has been determined, the following design aspects can be defined:

- What stylistic feeling will be most appreciated by the learners?
- Navigation: What navigation scheme will make the most sense for the users of the site? Learning styles may influence the learner in to wanting to choose their own path or wanting to be led down a pre-defined path, without having to make too many choices.
- Learning Style: To be an effective teaching and learning tool, each learning package needs to lead the learner into becoming an active participant rather than remain as a passive information receiver. To progress through a learning package, s/he must initiate triggers which move them through the material allowing interaction with the content and learning package on several levels. Learning packages must be constructed to allow progress through the material as the learner responds to the interactive cues. Rather than a linear path through the material, the material is whenever possible presented in the sequence set by the learner's responses and by what path the learner chooses to follow according to his/her individual learning wants and needs.
- Interactivity: Questions and comments that provoke learner interaction should be contained within the teaching material. The communication and virtual environment of the Internet permits interaction and participation to a far greater extent than traditional logistical constraints dictate. The key elements to successful virtual web-based learning are access, flexibility, responsiveness, and convenience.
- Content: There are a numbers of methods and systems (such as text, graphics, and animation) which may be employed for displaying the content. The content must be appropriate for the users of the site and be the most effective method for the learners.
- Technology: The technology must be appropriate for the users of the site. Information on the users is required such as:
- How will the server be accessed?
- What bandwidth will be used?
- What forms of media are found to be useful?

Learner Interaction with the Website Content and Information:

Web-based learning environment design must succeed in creating systems which learners can quickly, easily, and successfully navigate. If a learner gets lost in a website, can't find something quickly, or is bombarded with too much information, it is the design that has failed not the learner.

There are several functions that can measure the usability and success of an interactive experience:

- Predictability: The learner should be able to predict the consequences of actions. Natural mapping ensures that the predicted result of an action is the true result. For example, when a learner looks at a button, they should be able to predict what the result of pushing it will be.
- Consistency: The elements in the system must respond to a learner's actions in predictable, consistent ways. For example, a button that does one thing on one page should do the same thing from on pages.
- Natural Constraints: The system should anticipate error, and the design should avoid mistakes and ambiguity.
- Visibility: The elements must be visible and their function apparent. Controls, such as buttons, should have visual attributes that strongly identify them.
- Transparency: A learner's focus should be on the content not the interface. The interface must guide, but not become the centre of attention.
- Feedback: Each action a learner takes should have an immediate and obvious effect. Learners need to be able to quickly appreciate the results of their actions.

Pedagogic Principles

Learning packages should have specified objectives to be achieved concerning the content, the intellectual skills and the generic skills appropriate to the level of learning package. Content objectives should specify detailed content and the nature of learning. The latter should have greater emphasis on meaningful and integrated learning than on rote memorisation. Skills objectives should include specified types of knowledge acquired in a defined domain of applications. Generic skills objectives should refer to the contribution that learning makes to transferable skills that can be applied beyond the specific content of the program or course. A mapping document or skills portfolio may be integrated into the learning package material.

Assessment and Feedback

Methods of assessment should be related to the goals and learning objectives. The intellectual demand should be appropriate to the level of the learning package. Formative assessment may be implemented in a variety of ways such as multiple choice, matching, and 'fill-in-the-blanks'. The purpose of these feedback exercises is to provide the learner with the opportunity to verify comprehension of material immediately and allow him/her to proceed with confidence in their understanding of certain key points.

Self-diagnostic questioning has long been a feature of effective open learning in traditional print-based materials. The pattern has been for the information provider to pose a self-assessed question, then provide a suggested answer followed by an explanation. This model encourages the learners by posing a question, as in a classroom situation, and providing enough space for the learners to attempt a solution to the question. The information provider supplies enough material for the learner to assess performance diagnostically.

As part of this project a number of ready-made or "plug-and-play" pieces of HTML and JavaScript code have been produced. The aim of this exercise was to allow information providers access to assessment tools that can be included in their learning packages.

All the JavaScript examples have been written so that they may be pasted into a HTML code and so an information provider easily identifies the variables such as Question, Answers, Hints and Explanations. These variables can be changed to the information provider's own needs and enables them to use JavaScript techniques without requiring knowledge of programming. All that is required is a basic knowledge of HTML.

There are a number of options available to information providers:

Multiple Choice

Multiple Choice with hint

Multiple Choice with feedback on getting correct answer

Multiple Choice with hint and feedback

Equation-Balancing Exercises specific for reactions of the forms:

aA + bB —> cC

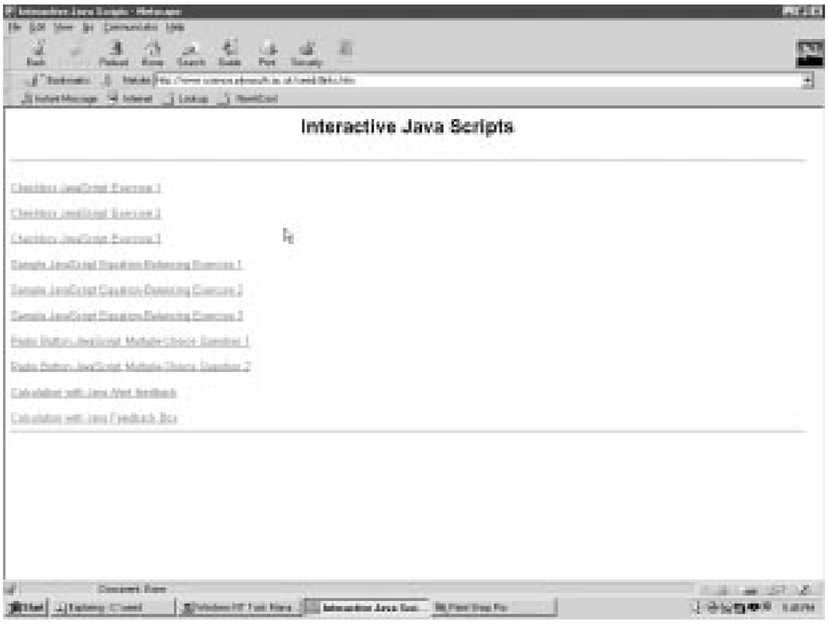
aA + bB —> cC + dD.

Mathematical equation questionnaire

A number of examples were created to illustrate the potential of JavaScript formative assessment processes to potential information providers. The listing of sample exercises is illustrated by Figure 10.

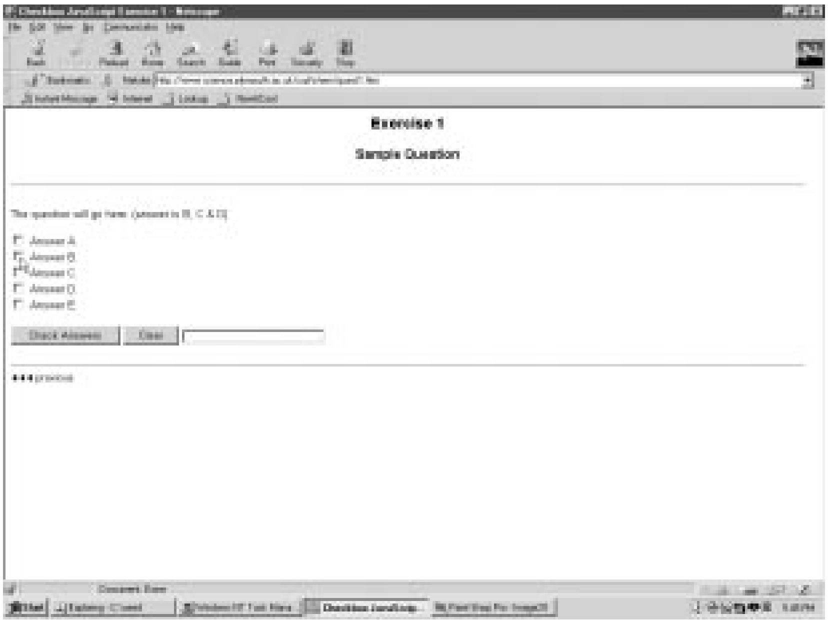
As they are for illustration purposes only, these samples include answers on the page as well as the question.

Figure 10 Listing of sample formative exercises



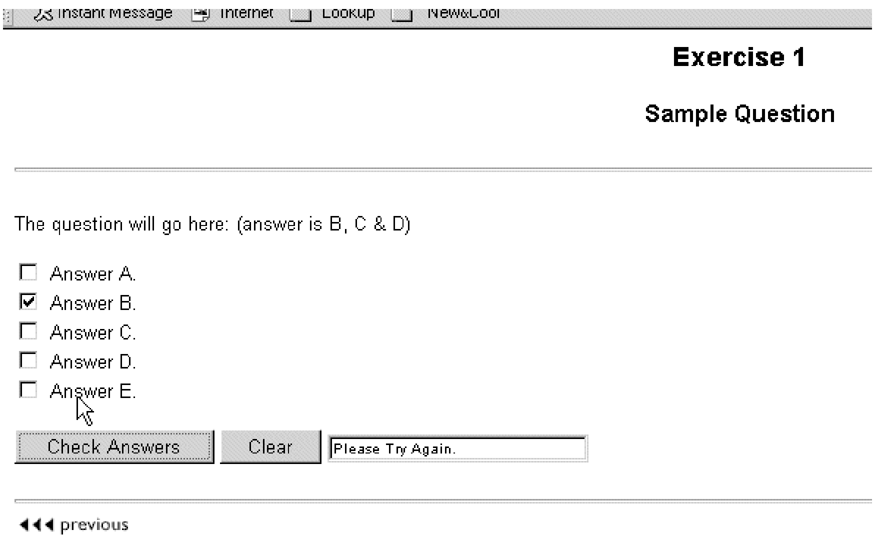
The format of the questions is limited using JavaScript/HTML features[18]. Figure 11 shows a basic question.

Figure 11. Sample question



The number of correct answers can be varied by the information provider: in the case of the example in Figure 11 there are three correct answers (B, C and D). If the learner selects the wrong answer s/he will be asked to try again or receive a suitable message supplied by the information provider. This is illustrated in Figure 12.

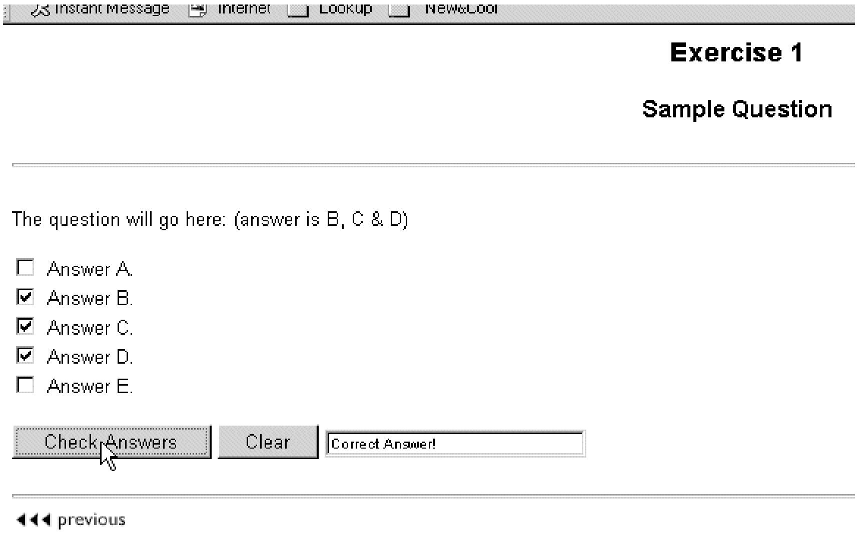
Figure 12. Sample question, with wrong answer



If the learner selects the correct answer, a suitable message is displayed as illustrated in Figure 13.

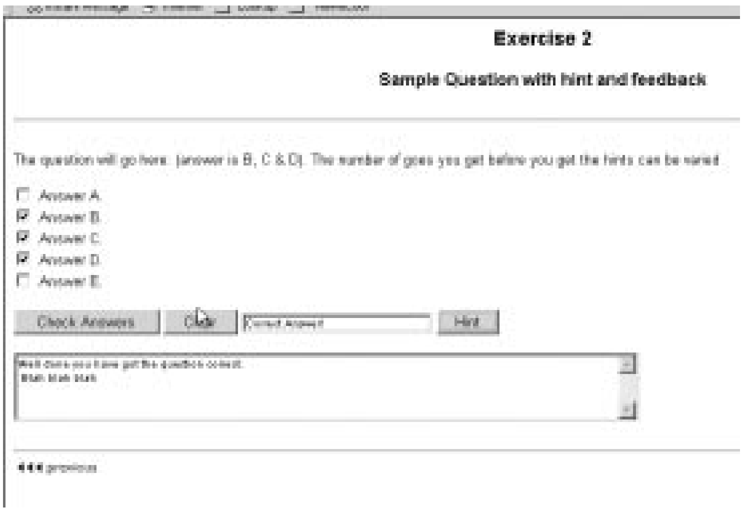
Figure 13. Sample question, with correct answer

This system of question delivery can be built upon. The example shown in Figure 14 shows the same question with a hint system. The learner can ask for a hint which will be displayed in the text area. The information provider is able to select how many attempts the learner must take before the hint is displayed.



When the learner has selected the correct answer, further information and reinforcing material is displayed in the text area.

Figure 14. Sample question, with hints and feedback



This type of Multiple Choice Questionnaire (MCQ) is not limited to text in the questions. It is possible to include streaming video, pictures and audio: however, there may be bandwidth issues if full multimedia is to be exploited. Graphics provide a method of illustrating questions, an example of which is shown in Figure 15. This example also shows that one page may have multiple questions linked by subject area.

Figure 15. Sample questions, with graphic

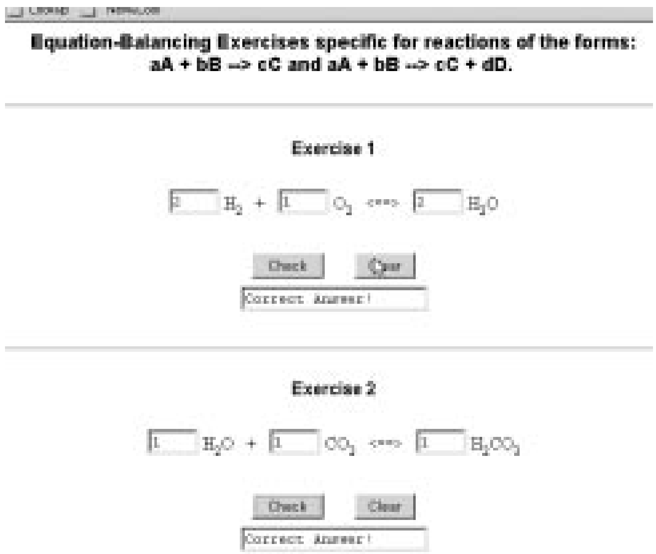
The investigation into formative assessment techniques was not limited to generic MCQs. The project team developed a number of JavaScripts for Chemistry assessments. Formative assessments were also developed for equation balancing exercises for reactions in the form of:

aA + bB —> cC

aA + bB —> cC + dD.

The interface for these exercises can be seen in Figure 16.

Figure 16. Equation balancing exercises



The 'toolbox' of assessment scripts has attempted to show as many examples and permutations as possible. The toolbox is still growing and other examples include the use of radio buttons instead of checkboxes (Figure 17) and the use of large numbers of possible answers (Figure 18). Updates to the toolbox have come from discussion with, and demonstrations to, colleagues who have expressed the need to allow their personal preferences in the construction of formative assessments.

Figure 17. The use of radio button

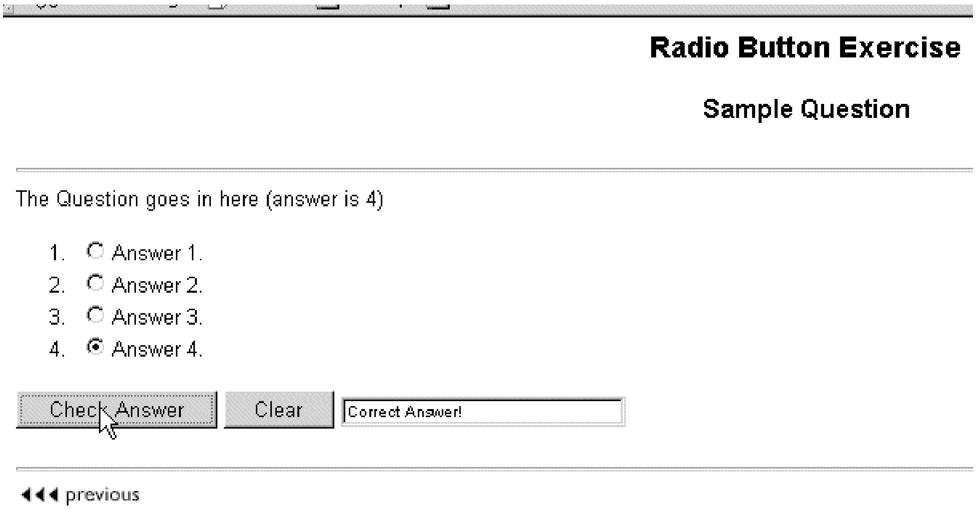
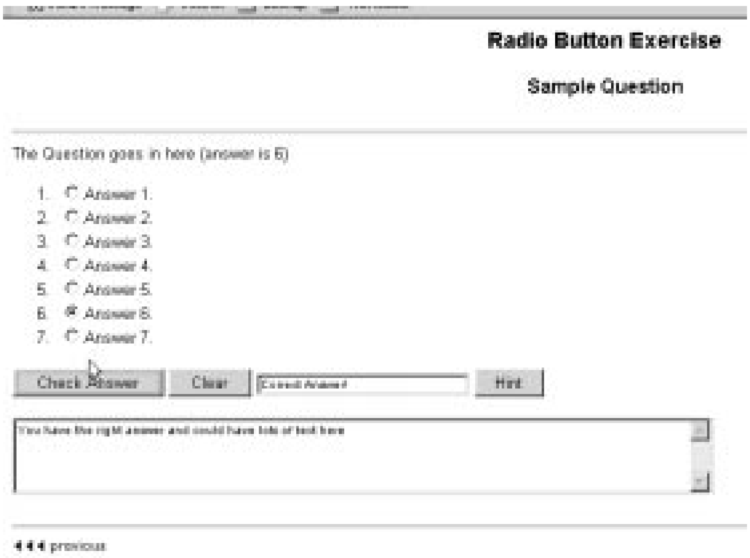


Figure 18. The use of more options for answers



Whilst the MCQ approach is a useful tool in testing the learner's understanding of principles, the assessment toolbox has been enhanced with the inclusion of calculation examples. Figures 19 and 20 show this method using Java alert boxes and in-line text areas to provide information or feedback.

Figure 19. Calculation with Java alert

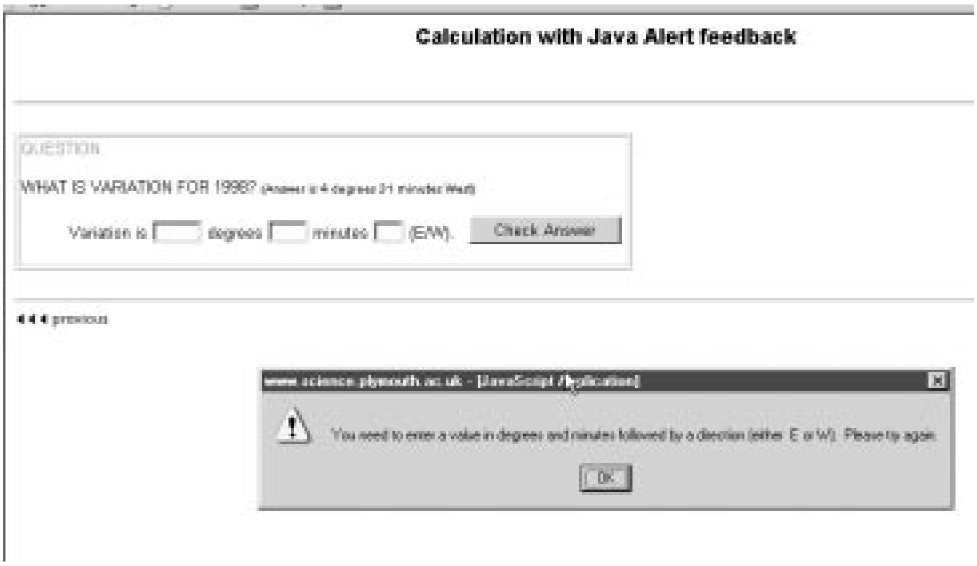
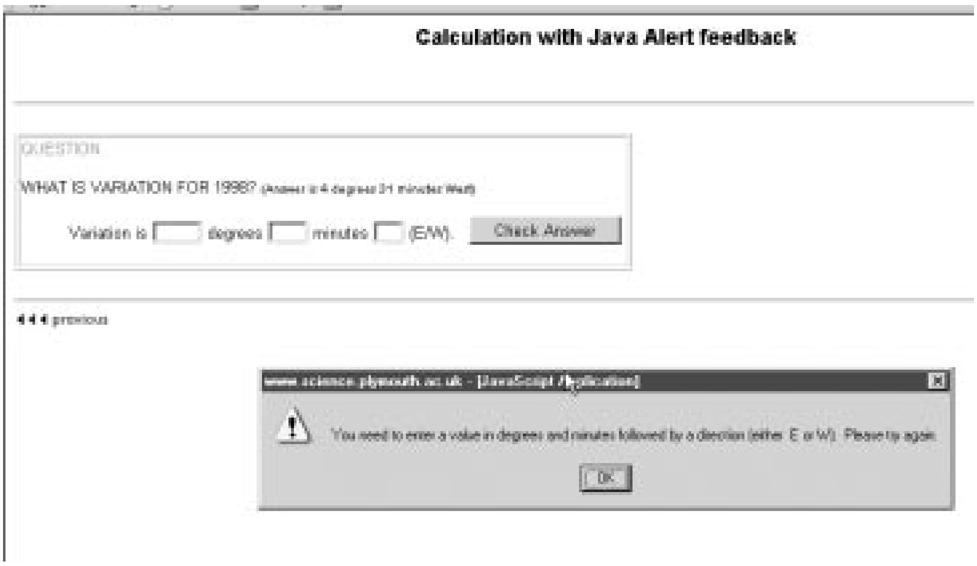


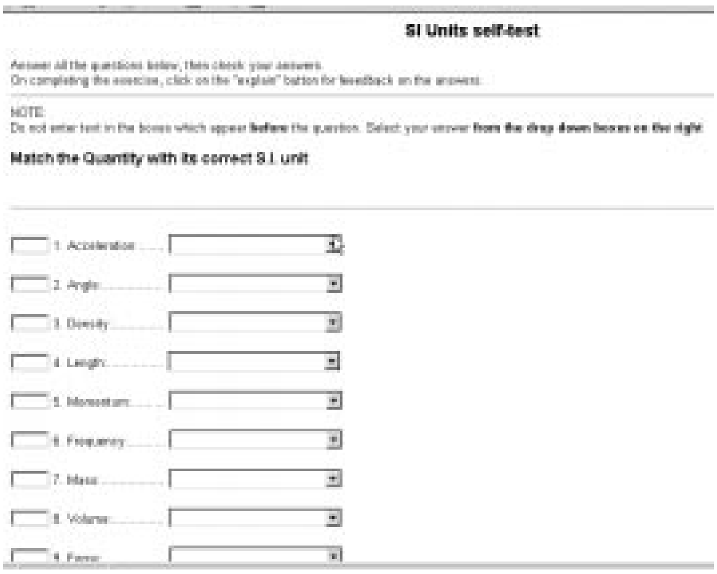
Figure 20. Calculation with feedback text area



In the calculation examples, the learner enters answers in the boxes provided. Pressing the “check answer” button without having entered a full answer calls up a prompt to complete the answer. Submitting an incorrect answer generates feedback on how to calculate the correct answer or gives further information. Submitting the correct answer leads to confirmation and further information may be presented.

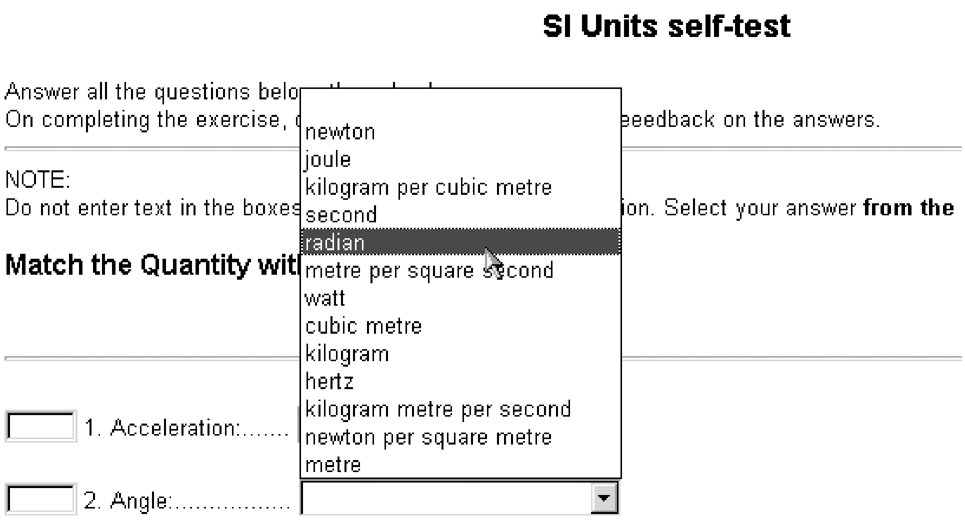
An alternative method of formative assessment is to allow the learner to select from a number of options from a drop down list, illustrated in Figure 21.

Figure 21. Drop down list exercise



The learner is able to select from a number of options, in this case to match Quantity with relevant S.I. Unit. This process is illustrated in Figure 22.

Figure 22. Example of a drop down list



When the learner has selected answers s/he can press the "Check Answers" button. The score will then be calculated and the marking of the answers shown in the left hand column. This is displayed in Figure 23.

Figure 23. Answer checking

If the learner has made some mistakes, clicking the "Show Correct Answers" button will display the correct answers. The information provider can select how many tries the learner has before the correct answers are displayed. This is shown in Figure 24.

Figure 24. Showing the correct answers

The learner's clicking in the "Show Correct Answers" does not affect the learner's final score. Once the assessment has been completed, the "Explain" button can take the learner to further material as illustrated in Figure 25.

Figure 25. Progression to further material

This approach is valuable to the learning process because the learner is provided with rapid feedback. The key feature from a self-study point of view is that the answers are hidden until the learner has attempted a response. The JavaScript has been written to prevent the learners from viewing the page source code to obtain the answers. The JavaScript creates the web pages "on-the-fly". By viewing the source code of a page created in this manner, the learner only has access to the HTML code of the page not the JavaScript code containing the answers.

Principles of good HCI-design

When exploiting the advantages of multimedia, the information provider should bear in mind the principles of good Human Computer Interaction (HCI) design, for both learning packages and assessment material. There are a rapidly growing number of display methods available to the web designer such as moving GIFS[19] Flash[20] and JAVA Applets[21]. The information provider should ensure that any embellishments enhance the pedagogic value of the material rather than purely concentrating on aesthetics.

The learner's attention should be focused on content. The mechanism of the interface should be transparent to the learner. The information provider should attempt to avoid multiple frames dividing up the screen unless this is appropriate. The central area of the screen should be used for content[22].

The screen perimeter should not be allowed to draw attention away from the important information on screen. Ideally it should either be a light neutral colour or be used to house buttons such as navigational tools.

The information provider must not assume that a learner will take n number of seconds to absorb a piece of information thus the learner must have control of the pace of delivery, unless pace is part of the teaching specification.

Movement on the screen should direct attention to important information; careless use of animations can distract and cause an annoying break in concentration.

Feedback

It is essential to obtain feedback on the material and techniques used in delivery of the learning packages from the learner. As the site contains material on diverse subject areas, it is not feasible to ask subject specific questions. The feedback questions are therefore generic and refer to the approaches and techniques used.

- The questions used in the feedback process are as follows:
- The material was easy to understand
- The material allowed me to proceed at my own pace
- The material allowed me to proceed in a logical manner
- The material allowed me to answer the questions I needed to
- The quality of graphics was high
- The graphics were appropriate
- The graphics were helpful
- The material enabled me to make connections I had not seen before
- The material allowed me to get a fuller picture of the subject
- This is a better way of presenting the subject matter than text-based
- This material would be better presented in a text book
- The material was a useful complement to a text book
- The material provided good background for lectures

A five-point satisfaction scale is used together with a comments section for additional information.

The process is automated and is illustrated in Figures 26 and 27. When the learner fills in and submits the form, the answers are simultaneously stored in a spreadsheet for analysis and sent via email to the information provider responsible for the learning package.

Figure 26. Generic feedback form

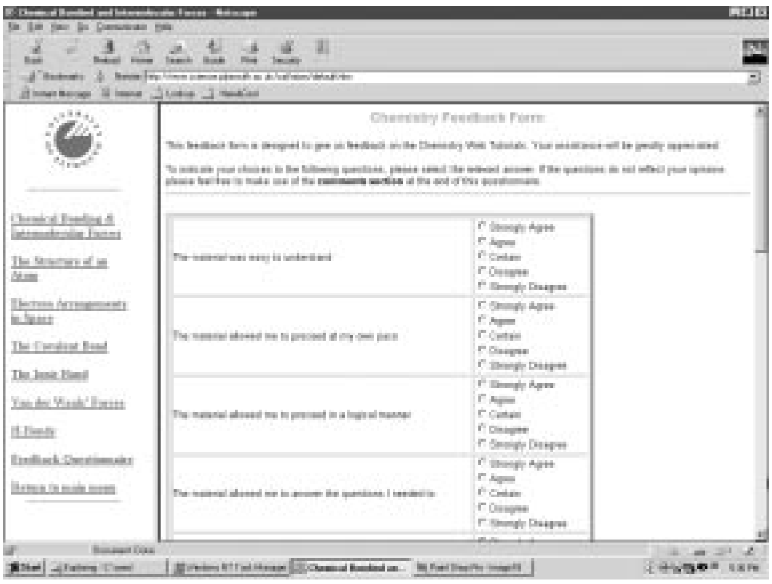
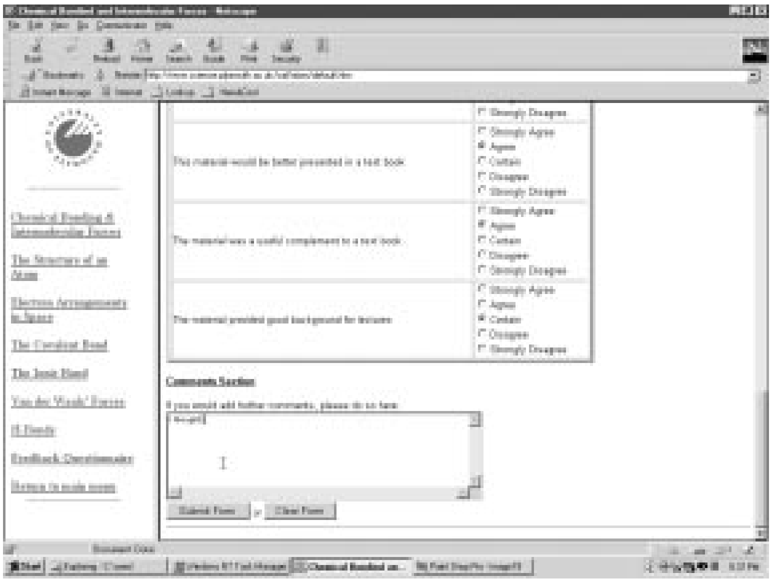


Figure 27. Generic feedback form with comments box



Conclusions

The outcomes of the project are:

- A website containing a number of learning packages relating to areas defined by Faculty staff. These areas are considered to be those where students are weak.
- A home for learning packages produced by information providers from the Faculty.
- A method of displaying material and approaches to staff interested in taking this route with their material.
- A number of formative assessment methods in a toolbox. These methods allow learners to assess their own learning.
- A number of innovative display mechanisms to aid the navigation of electronic based material.

References

1 McNab, A. (1994) "The Potential of the Internet for Teaching and Learning", LRJ, Vol. 10 No.3, pp 66-70.

2 Timms D., Crompton P., Booth S. and Allen P. (1997) "The implementation of learning technologies: the experience of Project Varsetile", Active Learning, No.6, pp3-9.

3 Hobby, J. (1996), "Net value", Personnel Today, 4 June, pp 31-36.

4 Dearing R. *et al* (1997) Higher Education in the Learning Society: Report of the National Committee of the Inquiry into Higher Education, London: HMSO and NCIHE Publications.

5 Jones P., Jacobs G. and Brown S. (1997) "Learning styles and CAL design: a model for the future", Active Learning, No.7, pp 9-13.

6 Fox, M. (1997) "The teacher is dead! Long live the teacher! Implications of the virtual classroom", Active Learning, No.7, pp 35-40.

7 http://www.plym.ac.uk/plymouth/about/about2.htm#uni

8 http://www.science.plymouth.ac.uk/departments/seed/

9 Varveri, F. S. J. Chem. Ed. 1993, 70, 204.

10 http://www.chemweb.com

11 HYPERLINK http://www.chemweb.com http://members.iworld.net/joo/physics/12 Tissue, B. M.; Yip, C. W.; Wong, Y. L. J. Chem. Ed. 1995, 72, A116.

13 Nielson, J. Hypertext and Hypermedia; Academic: Boston, 1990.

14 Hodges, M. E.; Sasnett, R. M. (Editors) Multimedia Computing: Case Studies from MIT Project Athena; Addison-Wesley, Reading, MA, 1993.

15 Cotton, Bob; Oliver, R. Understanding Hypermedia: From Multimedia to Virtual Reality; Phaidon: London, 1993.

16 Woodhead, N. Hypertext and Hypermedia, Theory and Applications; Sigma: Wilmslow, England, 1991.

17 http://www.shef.ac.uk/~chem/web-elements/

18 http://www.w3.org/MarkUP

19 http://www.wsdaents.com

20 http://www.macromedia.com

21 http://www.javasoft.com/applets

22 http://www.science.plymouth.ac.uk/departments/biology/genetics/

NOTES

THE SEED PROJECTS

***Project 1:* A web based bibliographic database on Science teaching and learning, designed to support the information requirements of the SEED Projects.**
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Tel: 01752 - 232318, E-mail: nmay@plymouth.ac.uk.

***Project 2:* An investigation of the potential development of Curriculum Support Teams.**
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***Project 3a:* A handbook on field teaching in the Sciences.**
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***Project 3b:* Field discovery days.**
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***Project 4:* Fieldwork issues and developments.**
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***Project 5:* A handbook on laboratory teaching.**
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***Project 8:* Development of a computer-aided learning package for environmental organic chemistry.**
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***Project 9:* Environmental issues in the Mediterranean: a case study of the Maltese Islands.**
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***Project 10:* Automated assessment in science: a review of good practice.**
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***Project 11:* CAL and basic Science.**
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***Project 12:* A handbook on employer-links in Science.**
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***Project 13:* Using multimedia for providing feedback to students undertaking concurrent project-based practicals.**
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***Project 14:* An environmental data base for projects in environmental impact assessment (EIA) and conservation.**
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***Project 15:* Webkit - a toolkit to produce interactive web pages in support of CAL.**
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***Project 16:* Qualifications update in applied Science for industry.**
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***Project 17:* Baseline assessment of competencies and skills for Science and Computing.**
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