Descriptive account

Web projects for Life Science students

Michael Hollingsworth, [1]Michael Mahon and Lucy Thomas

Faculty of Life Sciences, University of Manchester, Oxford Road, Manchester M13 9PT, [1]School of Medicine, University of Keele, Keele, Staffs ST5 5BG

Date received 03/08/04 Date accepted 10/09/04

Abstract

Eleven years experience with the running of web-based projects for final year undergraduate students of the Faculty of Life Sciences at Manchester University, along with an example of one project, is described. Application of the scientific method was emphasised to students. Technical support workshops were provided for them. Project performance and reports were assessed by similar criteria to laboratory-based projects. Since the 1993/4 academic year 316 web sites have been developed by students. The marks of students who did web-based projects since 1997/98 were 64.9 ± 0.5 % (mean ± S.E.M., n = 284), which was only slightly but significantly lower than the marks of students who did laboratory-based projects (66.6 ± 0.6 %, n = 1727, P < 0.01). Web-based projects are a robust alternative to laboratory-based projects. Students doing the former projects develop many of the same skills, other than practical skills, as those doing the latter projects but in addition develop the skills of questionnaire design and analysis and enhance their computing skills. Additional teaching materials have been produced as well.

Keywords: Computer-assisted learning (CAL), web projects, laboratory projects

Introduction

Projects are a normal component of the final year of undergraduate biological science degrees in the UK (Quality Assurance Agency for Higher Education, 2000a, b). Such projects have typically been laboratory-based where the students work alongside researchers. They aim to develop further the students' knowledge of the scientific method, to give them an appreciation of real research, an opportunity to work on a topic that is individual to them or in a small team and to develop many transferable skills (Boud *et al*., 1986). Typically students have to produce a final report, which as well as developing skills in report writing, is used as a method of assessment.

There are a number of pressures for change. The student:staff ratio has increased nationally in Biological Sciences over recent years. For example, it was approximately 10.3 in the Other Biological Sciences category in 1989/90 (Committee of Vice-Chancellors and College Principals and University Funding Council, 1991) but had increased to 14.5 in the Biological Sciences cost centre in 2001/2 (Higher Education Statistical Agency, 2003). Also, the funding per student has fallen from ~£5950 (in 2003 prices) in 1993/4 to

~£5615 in 2003 (Statutory Instrument, 1993; Higher Education Funding Council for England, 2003). Therefore, there has been pressure to develop less staff and cost intensive projects. There has been recognition that an increasing proportion of biological science students will not follow a career in laboratory science but will use their degrees in more diverse ways (Fantom, 2003). Consequently not all students have a strong desire to do a laboratory-based project. There have also been opportunities created by the development of computer technologies. Such technologies are now an integral part of teaching and learning materials (Hughes, 2003). Many staff have been involved in projects such as the Fund for the Development of Teaching and Learning, and the Teaching and Learning Technology Programme (FDTL and TLTP Co-ordination Team, 2000) and have learnt the benefits and pitfalls of such technologies when applied to their subjects. The development of the graphical web interface (Berners-Lee, 1999) has lead to new possibilities of delivery of teaching materials.

There have been brief reports on electronic-based student projects (Richardson *et al*., 1996; Sieber, 2003). Reported here are the results of 11 year's experience of the supervision of web-based projects for final year undergraduate students in a large Faculty of Life Sciences. In addition, the process is shown for one student (L.T.). Such projects have been a valuable addition to the variety of projects on offer and have provided some useful additional teaching materials. Preliminary results were presented at the International Union of Pharmacology conference 2002 (Hollingsworth *et al*., 2002).

Methods

Overall process

In the Faculty of Life Sciences, Manchester University, staff were asked to identify 3-4 project topics each year, which could be web-based as well as laboratory-based. Students were invited to nominate their project choices in rank order and selection was based on the best fit between student preferences and project availability. Students were informed of their projects and supervisors in early October and projects ran from mid November to Easter at the rate of two full days a week.

A key element in the running of web-based projects was to provide technical support. Although many students in more recent years had good general computing skills, few had any experience of web authoring. Similarly few staff had skills in web authoring or a desire to learn. Consequently a series of web project support workshops were offered. These workshops soon developed a broader remit (Table 1).

Table 1. *Content of support workshops.*

Application of the scientific method to web-based projects
Web authoring (including formal classes in HTML, Front Page Express, Flash, templates)
Sources of images and other resources
Copyright and legal use of the Internet
Questionnaire design and analysis
Student presentations

Students, and staff, needed advice on how to apply the scientific method to web-based projects as it was made clear that such projects were to be scientifically equivalent to laboratory-based projects. Students were encouraged to develop a clear set of aims or, even better, an hypothesis that could be tested. Advice was offered on how to identify the needs of the target audiences for the web sites and subsequently how to assess whether such needs had been met. Technical support from an information technology specialist was provided both by formal classes and one-to-one assistance. In recent years a small micro-computer laboratory has been dedicated to use by such students in addition to the usual computer clusters. It contains 8PCs equipped with standard Microsoft Office software, plus Front Page Express, MacroMedia Studio (containing Dreamweaver, Fireworks, Flash and Freehand), Illuminatus Opus, Paint Shop Pro and Hot Potato. Students would meet every few weeks and give short presentations of work in progress with questions and answers to deepen thinking. Students had to write reports identical in style to those for laboratory-based projects. Students were assessed on the basis of performance during the project (20%), a mark given just by the supervisor, and on their project report (80%), marked by the supervisor and a second marker. The criteria for assessment (Table 2) were adapted from the criteria used for laboratory-based projects, but only slightly. Comparison of marks between students who did web-based and laboratory-based projects was done by the Student's *t*-test. All completed web sites are accessible via the Faculty intranet to all staff and students conducting web-based projects. Staff can link specific web sites to teaching units and, if of sufficient quality, can ask for them to be available via the internet.

Table 2. *Criteria used to assess web-based projects*

Project performance (20%)	**Project report (80%)**
Appreciation of research problem Student input to web design Technical skills Organisational ability	Quality of web site Organisation of report Evaluation of web site Analysis of feedback Coverage and interpretation of the literature Standard of English

Individual project

This project was conducted as part of the final year of the BSc Pharmacology programme of Lucy Thomas in the 2000/1 session. The web site topic "Drugs and the Autonomic Nervous System" was produced in collaboration with Aquinas 6th form college, Stockport. It was aimed at upper 6th form students, mainly 16-18 year old students, doing the Assessment and Qualifications Alliance (AQA) syllabus B for Advanced level biology as well as for Life Science students undertaking the first level pharmacology unit at Manchester University. The literature relating to the scientific topic as well as the use of computer-based learning (CAL) and web sites as a teaching and learning aid was reviewed. Several computer-aided learning programs were assessed for the features that made them good or poor teaching aids. The computing skills and the teaching needs of the two target audiences were assessed by paper questionnaire (Fig. 1). This questionnaire was conducted among A-level students who would do the web site later in their course. The undergraduate students surveyed by email were second year students who had undertaken the pharmacology unit the previous session. The web site was designed using Front Page and Front Page Express. The final web site was evaluated by the two target audiences. A-level students were questioned by means of a paper-based questionnaire during a class session (Fig. 2a). University students were asked for their opinions by means of an on-line questionnaire that was part of the web site (Fig. 2b). As the questionnaires used questions of the Yes/No format or asked for answers on a 1-5 ordinal scale, analysis was by means of the χ^2-test or Mann Whitney U-test respectively using SPSS version 9.0.

Questionnaire for A-level students

A. How often do you use the school, or a personal computer, for educational and leisure purposes? Please tick one option from each column.

	Educational	Leisure
At least 3 times per week	[ ]	[ ]
At least once per week	[ ]	[ ]
Less frequently	[ ]	[ ]
Never	[ ]	[ ]

B. Have you ever done any of the following? Please tick all that apply.

	No	Yes, in lessons	Yes,out of lessons
Used a search engine to find Information about one of your A Level subjects	[ ]	[ ]	[ ]
Looked at a web site that your teacher recommended	[ ]	[ ]	[ ]
Used an educational computer programme, e.g. CD ROM	[ ]	[ ]	[ ]

C. Do you feel that computer packages are useful to your Biology A Level course?

Yes [ ]	No [ ]	Not sure [ ]

D. If you answered 'Yes' to the question above, why? Please tick as many options as are applicable.

To clarify material from lessons	[ ]		To help with revision	[ ]
Other (please specify)	[ ]		To learn more about a topic	[ ]

E. Which of these features do you think are important to have in an educational computer package? *Please circle one score for each, where 1 = unimportant and 5 = very important*

Pictures and diagrams	1	2	3	4	5
Information about the syllabus	1	2	3	4	5
Further information not covered in lessons	1	2	3	4	5
Quiz or self-assessment	1	2	3	4	5
Links to useful web sites	1	2	3	4	5
Animation	1	2	3	4	5
Recommended reading	1	2	3	4	5

F. Here are some topics you have covered in your Biology lessons. Please rate them on their degree of difficulty by circling a score for each, where 1 = very easy and 5 = very hard.

Understanding what agonists and antagonists do	1	2	3	4	5
Understanding what happens to acetylcholine after it is released from a neuron	1	2	3	4	5
Understanding how action potentials cause neurotransmitter release	1	2	3	4	5

F. Any other comments?

Specific to undergraduate students

Tell me how difficult you found these parts of the BS173 Pharmacology unit last year. *Please give each option a score from 1 to 5 (where 1 = very easy, 5 = very hard)*.

To understand definitions of agonist, antagonist and partial agonist	[ ]
To explain how drugs act at sites other than postsynaptic receptors	[ ]
To understand the concept of tone	[ ]
To understand the sequence of events by which drug action causes physiological changes	[ ]
To understand the roles of the sympathetic and parasympathetic divisions of the autonomic nervous system	[ ]

Figure 1: initial needs evaluation questionnaire conducted with A-level students and second year undergraduate students. The full questionnaire for A-level students is given above. The questionnaire for undergraduate students consisted of questions C (changed to "Undergraduate course"), D, E and G of the A-level students' questionnaire plus the additional questions.

Questionnaire for A-level students (2a)

What did you use the website for? *Please select all that apply*

To learn something new related to your Biology course	[ ]
To clarify what you had been taught in class	[ ]
To help you revise	[ ]
Other (please specify)	[ ]

For the following questions, please give your opinion by rating each feature with a score from 1 to 5, by circling a number. *It would really help if you could also briefly explain why you chose that score.*

			Comments
Colours and fonts			
Poor	**1 2 3 4 5**	Excellent	
Navigation around site			
Difficult	**1 2 3 4 5**	Easy	
Relevance to course			
Irrelevant	**1 2 3 4 5**	Relevant	
Aims of package			
Unclear	**1 2 3 4 5**	Clear	
The structuring of the site into topics, e.g. heart			
Confusing	**1 2 3 4 5**	Logical	
Presentation of information			
Poorly explained	**1 2 3 4 5**	Well explained	
Download times (waiting times for page loading)			
Relatively slow	**1 2 3 4 5**	Relatively fast	
Did working through the site improve your knowledge of the topic?			
Not at all	**1 2 3 4 5**	Significantly	
Total amount of information on website			
Far too little	**1 2 3 4 5**	Far too much	
How detailed the information was			
Far too little	**1 2 3 4 5**	Far too much	
Amount of information *not* directly covered in your course			
Far too little	**1 2 3 4 5**	Far too much	
Amount of time you needed to work through the site			
Far too little	**1 2 3 4 5**	Far too much	
The pictures and diagrams illustrating the site			
Far too few	**1 2 3 4 5**	Far too many	

Any other comments?

Undergraduate students questionnaire (2b)

1. Who are you?
   (A Level student / 1st yr undergraduate / other undergraduate / teaching staff / other)

2. For which of the following do you think the site most useful? Please select all applicable.
   To learn something new related to your course
   To clarify what you have been taught in lessons or lectures
   To help you revise
   Other (please specify)

3. Did you work through the site from start to finish at the appropriate level?
   Yes / No

4. To what extent do you feel that the site improved your knowledge of the topic?
   Not at all 1 2 3 4 5 Significantly

For questions 5-19, please select a score between 1 and 5 to rate the features mentioned.

5. Colour scheme and fonts (poor-excellent)
6. Navigation around the site (difficult-easy)
7. Structuring of site into topics, e.g. heart (confusing-logical)
8. Page downloading times (relatively slow-relatively fast)
9. Aims and objectives of package (unclear-clear)
10. Aims and objectives of package (none achieved-all achieved)
11. The presentation of the information (poorly explained-well explained)
12. Pictures and diagrams on the site (too few-too many)
13. Relevance of the site to your course (not at all relevant-completely relevant)
14. Total amount of information on the site (too little-too much)
15. How detailed was the information (too little-too much)
16. Amount of information not directly covered on course (too little-too much)
17. Amount of time needed to work through site (too little-too much)
18. Quiz (too easy-too difficult)
19. How confident are you that the information here is reliable? (not at all-completely)

Any other comments?

Figure 2: final evaluation questionnaire conducted with A-level students (2a) and first year undergraduate students (2b).

Results

Overall process

Between the 1993/4 and the 2003/4 academic years 316 students had undertaken web-based projects, with the numbers increasing year on year up to 2002/3 (Fig. 3).

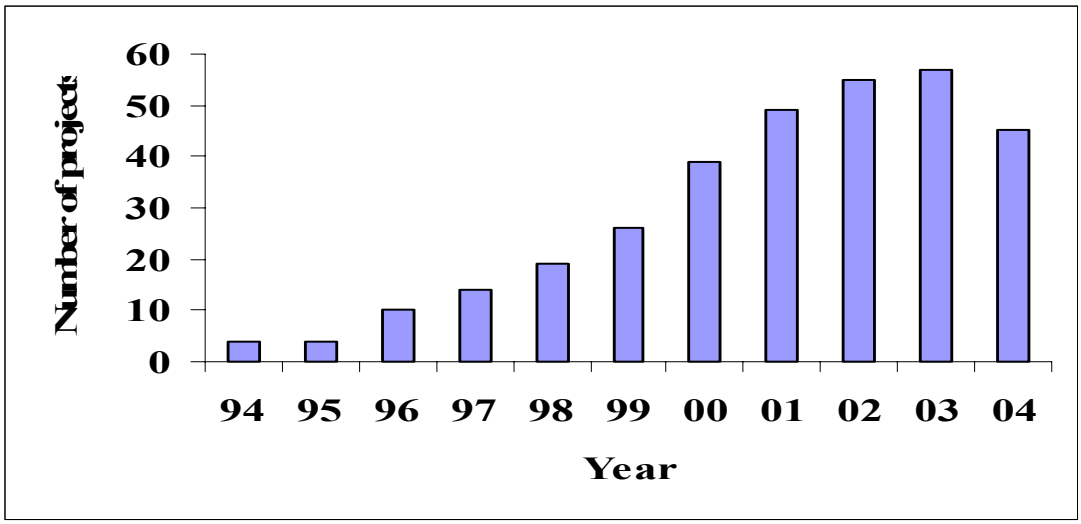

Figure3: number of web projects produced each academic year since 1993/4.

Since the 2000/01 academic year approximately 83% of students have done laboratory-based projects and 17% web-based projects. The numbers of supervisors has increased, with some 48 supervisors out of 110 academic staff in the 2002/3 academic year. The majority of web sites have been designed as supplementary resources to teaching conducted by staff, either for Life Science units or for medical and dental students. The topics have varied from anatomy to zoology, from the molecular level to whole man (Table 3). In addition, web sites have been aimed at school children aged from 5 to 18. Eighteen of these web sites are available via the internet (Yong, 2004) and are in regular use as teaching resources.

Table 3. *Examples of student-authored web sites (Yong, 2004), their target audiences and the aims of the students*

Title of web site	Target audience	Aim
Drugs and the autonomic nervous system	A-level and first year undergraduate students	Aid understanding of drug action on synaptic transmission
Insulin and glucagon	A-level and first year undergraduate students	Aid understanding of the actions of insulin and glucagons
Biological Clocks	A-Level and first year undergraduate students	Aid understanding the basic principles of biological timing
Choroid plexus	Introduction for Researchers and Postgraduate students	Increase awareness of rapidly evolving subject area
Cytogenetics	First year undergraduate	Introduction to cytogenetics
Monoclonal antibodies	Undergraduates	Overview of applied biotechnology
Imaging for Idiots	Medical students and undergraduate Biological Science students	Aid understanding of Magnetic Resonance and Computerised Tomography scanning
Principles of Magnetic Resonance Imaging	Medical students, Senior house officers, Anatomical and biomedical science students	Aid the understanding of magnetic resonance imaging, a difficult topic.
Control and manipulation of the hypothalamic-pituitary system	Second year undergraduate Biological Science students	Aid understanding of the mechanisms through with the hypothalamus and pituitary gland are functionally interrelated

Figure 4 shows the assessment of web projects in comparison with laboratory-based projects since the 1997/8 academic year, the year from which there were significant numbers. The figure demonstrates the consistency of marking from year to year. In most individual years there was no significant difference in the mean marks for the two categories of projects. However, overall the mean marks for students who did web-based projects was 64.9 $\pm$ 0.5 % (n = 284), slightly but significantly ($P < 0.01$) lower than for students who did laboratory-based projects (66.6 $\pm$ 0.6 %, n = 1727; Student's' *t*-test).

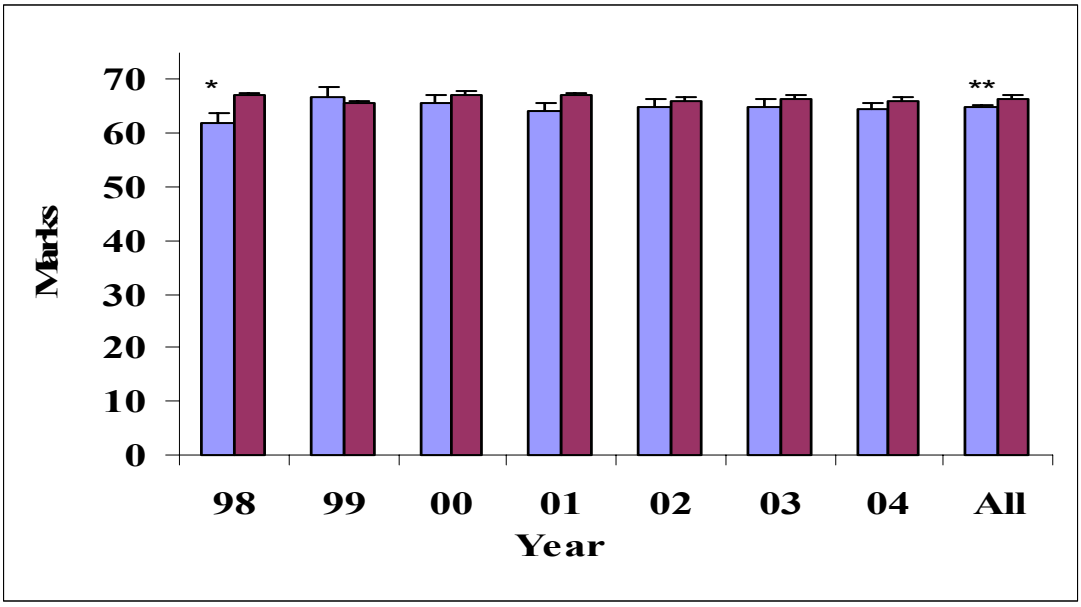

*Figure 4: marks for web projects. Values are means ± S.E.M. Significant differences between the groups are denoted by * (P < 0.05) or ** (P < 0.01, Students t-test).*

Individual project

The following features of web sites were identified as enhancing their value as a teaching and learning aid: easy navigation, good use of colour, logical organisation, interactive elements, clear objectives, and content pitched at the correct level for the syllabus.

Table 4. *Results of the initial needs evaluation questionnaire by A-level students (n = 85, 53% of the cohort) and undergraduate students (n = 45, 23% of the cohort). Data are presented as % or medians with inter-quartile ranges. * = Significant difference between A-level and undergraduate students (P < 0.05, χ^2 or Mann Whitney U-test).*

	AL	UG
Think educational CAL programs are useful	45.9%	84.4%*
Useful for:		
Clarification	69%	76%
Additional learning	49%	61%
Revision	85%	79%
Useful features:		
Pictures & diagrams	5 (4-5)	5 (4-5)
Syllabus details	5 (4-5)	4(3-5)
Additional material	3 (2-4)	3(2-4)

The results of the initial needs evaluation are summarised in Table 4. The A-level students had a reasonable level of computer use, as 81% used a computer at least once a week and 94% had looked at teaching web sites or other forms of computer-assisted learning materials. University students were more likely to believe that web sites were educationally useful. Both groups felt they would be useful for clarification of taught material, for additional learning and for revision. Both cohorts considered the following features of importance in a teaching package: pictures and diagrams, syllabus details and quizzes, and felt less strongly about additional learning materials and animations. Apart from syllabus details, there were no significant differences in the scores given by the two groups of students.

As there were two target audiences, it was decided that the web site (Thomas, 2001) should be at two levels after a common entry page. The pages aimed at University students had material in common with that of A-level students plus additional material. The topic areas covered were:

- structure and neurotransmitters of the autonomic nervous system
- actions of acetylcholine and noradrenaline on the heart, respiratory system and eye
- quiz

Both groups of students rated the web site highly in terms of clear aims, relevance to course, ease of navigation, colour scheme and fonts, illustrations, information presentation and perceived knowledge gain (Table 5). They felt that the total and level of information and time required to use the site were about correct. The A-level students felt that they had gained more knowledge by using the site than did the undergraduate students.

Table 5. *Results of the final evaluation questionnaire by A-level students (n = 38, 24% of the cohort) and undergraduate students (n = 13, 6% of the cohort). Data are presented as % or medians with inter-quartile ranges. * = Significant difference between A-level and undergraduate students (P < 0.05, Mann Whitney U-test).*

	AL	*UG*
Aims clear	*4 (3-4)*	*4 (3-4.5)*
Relevance to course	*4 (3-4)*	*4.5 (3.3-5)*
Ease of navigation	*4 (4-5)*	*4.5 (4-5)*
Information presentation	*4 (3-5)*	*4.5 (4-5)*
Perceived knowledge gain	*4 (3-5)*	*3 (2-3)**

Discussion

Individual project

There should be caution in drawing conclusions from the questionnaires, as although sometimes the numbers of students responding were large, they were generally less than 50% of the cohort. Also, data was not collected in the same manner for all groups. Therefore, conclusions drawn from the data may be biased. Notwithstanding those comments, the features that the students in the two target audiences rated highly in web sites were similar to each other, to those rated highly by the project student and to those recorded

in the literature (Abdullah, 1998). These similarities gave confidence when designing the web site. The A-level students rated web sites less useful than did University students. This difference might be explained by the lesser use of such teaching materials by the former group of students. The final web site was rated highly by both cohorts of students and demonstrated that features thought to be important had been incorporated into the site. Although students felt they had gained knowledge, in the time available it was not possible to objectively measure knowledge gain by the students using the web site. However, it would be possible to do such a study (Dewhurst *et al*., 1994). The web site is now used as a supplementary resource for both cohorts and is available on the internet (Thomas, 2001).

Overall process

Several lessons have been learnt from the 11 years of experience, both strengths and weaknesses of the approach. The workshops were an efficient method of providing technical support to large numbers of students (45 in 2003/4). These workshops were the equivalent of the individual technical support that most students receive during laboratory-based projects. They set standards in terms of quality of the scientific method and ensured that topics such as copyright issues and plagiarism were covered. They provided a forum for student-student and student-staff interaction. These workshops have been optional and some numbers of students have not attended. In future it is planned to make some workshop elements compulsory. In addition, students are to be organised into small teams and they will be expected to formally present work in progress to their team and supervisors. The aim is to raise the standards of the scientific methods used, final web site and statistical analysis.

Students have gained knowledge and skills. They have gained knowledge of the topics of their web sites. They have developed many of the same skills as with a traditional laboratory-based project such as the scientific method, time organisation, planning, statistical analysis, report writing and working to deadlines. In addition, they have developed many skills almost unique to this type of project, such as questionnaire design, conducting surveys, communication of science and, of course, have significantly increased their computing skills, in particular web authoring. These skills are very relevant to many careers (Fantom, 2003) and some students have gained employment partly as a consequence of their project. They have obviously failed to develop practical laboratory skills. However, many of these students have not gone on to use such skills in employment.

For staff, web-based projects can be less time-intensive and less costly than laboratory-based projects. The technical support has been provided centrally so removing the need for staff to have web authoring skills. Such projects have had the additional benefits of encouraging staff to think about the teaching they deliver and add variety to their teaching methods. Useful web sites have resulted to enhance the quality of teaching.

Concern has been expressed that such projects do not have the intellectual rigour of traditional laboratory-based projects. In the best of the latter projects, they are student-led where the student erects an hypothesis and he/she devises experiments to test the hypothesis (Beard & Hartley, 1984). The role of the supervisor is to teach techniques and give guidance. In reality, many laboratory-based projects are more routine. It is difficult to erect hypotheses for web-based projects that can be tested within the time limits of the project. Students can be expected to have clear aims for their web site and their project, and assess whether those aims have been met. Another concern is the superficiality of the science covered by the students doing a web-based project as they are generally aimed at first and second undergraduates or school students. This concern assumes that all laboratory-based projects are at the cutting edge of research, which is often not true, and a minority of students do not do any project in their final year (Quality Assurance Agency for Higher Education, 2000a, b). To communicate science to school or undergraduate students, the project students do need to understand their topic at a deeper level. In the future that students doing web-based projects will additionally be required to write an in-depth review of the relevant literature.

It has been important to assess students doing web projects by similar criteria to those doing laboratory-based projects. The reason is that laboratory-based projects are considered by most staff as the 'gold' standard against which other projects are judged. The use of similar assessment criteria for web- and laboratory-based projects helps to ensure equal standards. The results (Fig. 4) show that the performance of students doing web-based projects was similar but slightly lower than that for other students. The similarity of performance demonstrates that the criteria are equivalent. The slightly lower performance overall could be for a number of reasons. The first reason could be that students doing web-based projects are less able. The second reason could be that such students do less well in their projects. The third reason could be that staff mark such projects harder. It is not possible to distinguish between these explanations.

In summary, web-based projects are a robust alternative to laboratory-based projects. It is important that they are viewed by staff and students as scientifically equivalent and that technical support is provided. A bonus with such projects is that valuable teaching materials can be developed.

Communicating author Dr Michael Hollingsworth, Faculty of Life Sciences, G38 Stopford building, University of Manchester, Oxford Road, Manchester M13 9PT; Tel 0161-275-5489; Fax 0161-275-5600; mike.hollingsworth@man.ac.uk

Acknowledgements

We wish to thank all the staff and students involved in such projects, Alison Humphrey and Louisa Yong for technical support, Dr David Minors for statistical advice, Mr Roger Starling for financial advice and the collaboration of Mrs Linda Harden, Aquinas College, Stockport.

References

Abdullah, M.H. (1998) Guidelines for evaluating web sites. ERIC Digest, http://www.ericfacility.net/databases/ERIC_Digests/ed426440.html Accessed August 3rd 2004.

Beard, R. and Hartley, J. (1984) *Teaching and Learning in Higher Education*. 4th Ed. London, UK: Harper and Row.

Berners-Lee, T. (1999) *Weaving the Web: the origins and future of the World Wide Web*. London, UK: Orion business.

Boud, D., Dunn, J. and Hegarty-Hazel, E. (1986) *Teaching in Laboratories* Guildford, UK: The Society for Research into Higher Education.

Committee of Vice-Chancellor's and College Principals and University Funding Council (1991) *University Management Statistics and Performance Indicators in the UK: 1991 Edition and relate to CC11, Other Bio Sciences*.

Fantom, P. (2003) What do graduates do? 2003, http://www.prospects.ac.uk/cms/ShowPage/Home_page/What_do_graduates_do__2003/p!ekIFie Accessed August 3rd 2004.

Fund for the Development of Teaching and Learning, and Teaching and Learning Technology Programme National Co-ordination Team (2000) TLTP Projects, http://www.ncteam.ac.uk/projects/tltp Accessed August 3rd, 2004.

Higher Education Funding Council for England (2003) Guide 29 Funding higher education in England – how HEFCE allocates its funds, p9. Available on http://www.hefce.ac.uk/Pubs/hefce/2003/03_29/03_29.doc Accessed August 5th 2004.

Higher Education Statistical Agency (2003) *HESA disk, Planning Plus 2003, and relate to CC10, Biological Sciences.*

Hollingsworth, M., Mahon, M and Thomas, L. (2002) Web projects: education and assessment in the scientific method and extra resources as a result. In: *Teaching Pharmacology Tomorrow: Tools and Techniques*. Ed. Davies, E.A. Proceedings of the IUPHAR Teaching section, Monash University, Melbourne.

Hughes, I.E. (2003) Changes in the use of technological methods of teaching and learning in undergraduate pharmacology in UK Higher Education. *Bioscience Education e-journal,* **1** (1), 1-7. http://bio.ltsn.ac.uk/journal/vol1/beej-1-1.html Accessed August 3rd 2004.

Quality Assurance Agency for Higher Education (2000a) QAA Review reports – subject level – Organismal Biosciences http://www.qaa.ac.uk/revreps/subj_reports.asp?subjID=87 Accessed August 3rd 2004.

Quality Assurance Agency for Higher Education (2000b) QAA Review reports – subject level – Molecular Biosciences http://www.qaa.ac.uk/revreps/subj_reports.asp?subjID=84 Accessed August 3rd 2004.

Richardson, H., Mahon, M., Cunningham, M. and Miller, I. (1996) Student development of interactive multimedia computer assisted learning (CAL) packages for undergraduate study. *Journal of Physiology*, **496**, 8-9.

Sieber, V. (2003) Electronic projects for final-year students *LTSN Bulletin*, **10,** 9

Statutory Instrument (1993) *No. 1850 The Education (Mandatory Awards) Regulations, Schedule 1, Paragraph 2*

Thomas, L (2001) Drugs and the autonomic nervous system, http://cal.man.ac.uk/student_projects/2001/mnqb8lgt/ Accessed August 3rd 2004.

Yong, L. (2004) Computer-assisted learning (CAL) resources, http://cal.man.ac.uk/student_projects/validated_projects.asp Accessed August 3rd 2004.