Evaluation of a distance-learning immunology and pathology module in a postgraduate biomedical science course

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ABSTRACT

An electronic presentation of materials for a distance-learning immunology and pathology module from a postgraduate biomedical science course is evaluated. Two different electronic presentation formats for the delivery of the educational material to distance learners are assessed. Responses from users of this material highlighted a preference for a format that has a design tailored to distance learning. There was no significant difference in learning outcome between those taking the module on campus and by distance learning. This suggests that the prerequisites for entry, learning materials and direction given to the students studying by distance learning are adequate for these students to achieve the learning objectives outlined in the course. The evaluation also gave direction for areas within the (CAL) application that can be improved for future students.

KEY WORDS: Computer-aided learning. Biomedical science. Distance learning.

Introduction

Higher education has catered traditionally for a relatively narrowly defined group of people, with the inevitable result that many groups of people who do not fit the traditional student stereotype are excluded. In many cases, distance learning, as a form of flexible learning, has resulted in improved access to education.[1]

A trend towards distance learning is also evident in biomedical science. The Institute of Biomedical Science[2] has accredited a number of courses with a distance-learning option. For example, the University of Ulster (www.ulster.ac.uk/) offers a postgraduate diploma and MSc in biomedical science as a distance-learning option. In addition to its full distance-learning programme, the university also offers a postgraduate certificate in biomedical science that includes several distance-learning modules (Table 1).

Introduction of distance-learning options in the postgraduate certificate was made in response to calls from students and employers for more flexible modes of study. The postgraduate certificate, which is postgraduate in time rather than level (modules studied are all undergraduate Honours level), functions as a 'top up' qualification, allowing non-biomedical science graduates to develop an understanding and knowledge of recent advances in biomedical science.

It is important to note that at the time of the study the University of Ulster was in the process of reviewing the terminology used to describe its programmes. To better align with the National Qualifications Framework, the postgraduate certificate has, since the completion of this study, been renamed a graduate certificate to better reflect the fact that the programme is postgraduate in time rather than level.

Providing students with a choice of study media enables an exploration of learning outcomes associated with traditional campus delivery and distance-learning delivery, in what is essentially a natural experiment. A number of studies have explored learning outcomes associated with distance learning;[3-7] however, few have compared the two modes of study directly.[8,9]

This paper describes the evaluation of a computer-aided learning package specifically designed as an alternative to traditional on-campus lectures in an immunology/pathology module. Students were offered the opportunity to study by distance learning using a CD-ROM that contained material for their course, or by the traditional mode of delivery. The aim of the evaluation was two-fold: first, to assess whether or not there were differences in assessment outcomes between the groups; and second, to evaluate the courseware itself.

Materials and methods

Students registering for the certificate course elected to study the immunology and pathology module by either traditional face-to-face delivery or by a more flexible distance-learning option using a CD-ROM as a learning aid. Learning outcomes for these two groups of students were assessed using a mixture of continuous assessment and unseen examination paper. Assessments were identical for both sets of students. An anonymous marking scheme employed by the university meant that all continuous and examination scripts were marked blind. The CD-ROM utilised by distance-learning students was created

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Table 1. Structure of University of Ulster postgraduate certificate course.

Semester	Module Title	Mode of delivery		Credits
		Attendance	Distance learning	
1st	Immunology and Pathology*	Yes	Yes	15
	Designed to provide understanding of key concepts in immunology and pathology sufficient to underpin further study in the biomedical sciences.			
1st	Haemotology	Yes	No	15
	Provides a comprehensive overview of haematology. It covers all the major areas of haematology including haemopoiesis, leukaemia, haemostasis and general aspects of transfusion science. Provides the student with the appropriate knowledge and intellectual skills to work in a routine or research laboratory setting.			
	or			
1st	Microbiology	Yes	No	15
	Provides insight into the major historical events, discoveries, disciplines, activities and relevance of microorganisms to the different areas of human activity. A major goal is to provide a foundation for understanding and learning microbiology as a biological science and its relation to our public health and the environment.			
	or			
1st	Biochemistry	Yes	No	15
	Designed to introduce students to the fundamental biochemical pathways, an understanding of which are necessary for the further study of life and health sciences. The structure, function and metabolism of biological macromolecules and the regulation of the pathways involved in their metabolism are discussed in detail.			
2nd	Molecular Pathology*	Yes	Yes	15
	Presents in-depth consideration of the cellular and molecular biology of the major non-infectious diseases of humans. The module enables students to integrate practical and theoretical information gained in earlier modules. Current and emerging strategies in disease diagnosis, treatment and monitoring are also discussed			
2nd	Infection and Immunity	Yes	No	15
	Provides a detailed insight into the interaction between a microbial pathogen and its human host. The interaction between microorganisms and the immune defence mechanism is highlighted. Consideration is also given to the use of vaccines and chemotherapy to avoid and eliminate infection. The module is taught by a combination of lectures and seminars.			

*students choose to study either by attendance or distance-learning

specifically to provide them with all the material required to obtain the course objectives.

Text and images on the CD-ROM were compiled using Adobe PageMill web editor (version 3.0 for Windows; www.adobe.com/products/pagemill/main.html). Photographic images and diagrams were edited and optimised for web publication using Adobe Photoshop 5.0.2 (www.adobe.com/products/photoshop/main.html). The interactive web-authoring tool HotPotatoes produced by Half-Baked software (http://web.uvic.ca/hrd/halfbaked/) was used to create the end of lecture quizzes. The material was presented in a web browser format (www.microsoft.com /windows/ie/default.htm). The material used in the CD-ROM was based on that used in the on-campus lectures. However, the CD-ROM included additional supporting images and diagrams, as well as end-of-lecture formative assessments designed as quizzes to test students on specific concepts. Additional instruction was given to students on recommended reading.

Evaluation

The application was evaluated using questionnaires that the students were requested to complete during their on-campus lectures. The general usefulness of the CD-ROM package and student attitudes to specific aspects of the CD-ROM were evaluated using questionnaires (Table 2), and students were encouraged to qualify their responses with additional qualitative information. This permitted further exploration of student attitudes and clarification of the quantitative results and also highlighted aspects not covered in the more specific questions. Other areas evaluated included: computer competence (Table 4) and usability of the software (Table 5).

Student performance was evaluated by overall continuous assessment mark and final examination results. All students (including those studying by distance learning) studied at least two of the four modules that comprise the postgraduate certificate by attendance on campus.

All aspects were assessed using Likert scales. In addition, students were asked to keep a log, where they could make general comments about the CD-ROM as they were using it.

Comparison of presentation formats

An exploration of presentation formats was carried out on the two subject areas (immunology and pathology) covered in the module.

Table 2. Evaluation questionnaires completed by students.

Questionnaire	Format	Aim
A	***Quantitative*** (Likert Scale, 5 pt) ***Qualitative*** - Users were encouraged to qualify their scores with qualitative information	To evaluate student attitudes to aspects of the computer application (usefulness and content). Both Pathology and Immunology were evaluated separately so that comparisons could be made.
B	***Qualitative*** - Users were encouraged to make comments on the program as it was used.	To allow students to comment on the CD-ROM as they used it. This picked up typing and content errors. This allowed students to freely express their comments about the CD-ROM as they used it.
C	***Quantitative*** (Likert Scale 10 pt) ***Qualitative*** - Users were encouraged to qualify their scores with qualitative information	This allowed students to rate the CD-ROM in terms of its ease of use, layout, aesthetics etc.
D	***Quantitative*** (Likert Scale 5 pt) ***Qualitative*** - Users were encouraged to qualify their scores with qualitative information	This allowed an examination of the level of familiarity with, and attitudes to, computer applications and computers in general.

Presentation of the immunology section replicated the structure of the on-campus lectures in terms of content, format and order. Generally, each lecture was a prerequisite for the next. This type of presentation is similar to a traditional correspondence course, except that it is in an electronic format.[10]

The pathology section of the module was divided into modular sections (i.e., organs and systems). Aims and learning objectives were outlined and sections began with an overview of the major diseases effecting each organ or system, supported by images relevant to the most common diseases. Multiple-choice questions (MCQs) were included at the end of each section, so that the student could test their knowledge of the material studied. These questions were chosen to examine comprehension as well as knowledge.[11]

The immunology and the pathology sections were evaluated separately for content and usability (Table 3). A Likert scale (representing Agree, Neutral and Disagree) was used by students to respond to statements about satisfaction with the use of the CD-ROM. The statements were devised to explore possible areas of concern about the design and presentation of both formats.

In the questionnaire, students were also given the opportunity to clarify their quantitative ratings of each area with qualitative responses. All descriptive statistical analyses were carried out using Minitab. Differences in learning outcomes between the two groups (as assessed by continuous assessment and examination results) were assessed in Minitab using independent *t*- tests.

Results

Of the 18 students registered for the distance-learning course, eight responded to and completed the questionnaire. There was a positive response to the CD-ROM in general from at least half of the respondents (Table 3). Most respondents had an adequate level of computer literacy required to use the application (Table 4).

From the quantitative results (Tables 3 and 5) it was clear that students were generally much happier with the format and usability of the pathology section. However, some students would have liked more guidance on what was expected of them in the unseen examination, and how much extra reading they were expected to carry out. The quantitative ratings showed that students rated the pathology section higher than the immunology section on all usability criteria (Table 5).

In terms of learning outcomes, as judged by examination results (Table 6), there was no significant difference between students studying by distance learning and those who chose to study by attendance (Table 6). However, there was a significant difference in outcome ($P<0.05$) in the scores obtained by these groups in the haematology module (studied in face-to-face mode by all students), with the distance-learning group scoring significantly lower in the examination.

Discussion

The evaluation exercise was formative[12,13] and investigated issues such as content, usability and design. The software was essentially a prototype designed as much as possible to cater for the perceived learning needs of distance-learning students; however, layout and content can be optimised by learner feedback.

The evaluation was illuminative,[14] aiming to uncover unanticipated problems encountered by the students. Hence, students were encouraged to qualify all their quantitative responses with qualitative remarks, and they were encouraged to comment freely on all aspects of the course. Students were also asked to give an indication of their level of computer literacy, which is important if the application is to be integrated successfully into their learning habits.[15]

Usability

Supplying information by CD-ROM posed many advantages over printed material (e.g., ease of distribution, possible future publication on the internet, and the incorporation of interactive quizzes). This electronic format could also impose a structure to the information, allowing inclusion of numerous colour photographs and diagrams.[16]

However, it is important that this format does not become a barrier to learning. As can be seen in Table 5, respondents rated the main usability criteria positively in the pathology section. The weakest scoring area in both the pathology and immunology section was 'ease of navigation'. On further exploration, students qualified this by explaining that they

Table 3. Questionnaire A. Evaluation of the users' (n=8) attitudes to aspects of the computer application.

Questions relating to the CD in general	%Agree	%Neutral	%Disagree
I found the CD useful	50	25	25
I was interested in the CD before I used it	50	25	25
I find it easy to incorporate the CD as part of my learning habits	50	12.5	37.5
The learning objectives were clearly defined	50	12.5	37.5
Questions Relating to Pathology section	**%Agree**	**%Neutral**	**%Disagree**
The CD helped me understand the main concepts of pathology	75	12.5	12.5
The CD underestimated my understanding of pathology	0	37.5	62.5
The CD overestimated my understanding of pathology	25	50	25
The CD provided me with all the information I required	25	25	50
I had to supplement this CD to large extent with books	50	37.5	12.5
I found books more useful than the CD	12.5	50	37.5
I found the quizzes at the end particularly useful	50	12.5	37.5
I would have preferred the quizzes to be longer and more detailed	50	37.5	12.5
I wish the topics had been discussed in more detail	50	37.5	12.5
The images were placed inappropriately	12.5	25	62.5
The images were of good quality	75	12.5	12.5
I would like the application to be more interactive	62.5	25	12.5
The application didn't provide enough guidance	25	25	50
I had difficulty finding specific topics	12.5	37.5	50
I would have liked the application to be more structured	25	50	25
Questions relating to Immunology section	**%Agree**	**%Neutral**	**%Disagree**
I found the CD useful in my study of Immunology	37.5	12.5	50
This CD helped me understand the main concepts of Immunology	50	12.5	37.5
The CD underestimated my understanding of Immunology	12.5	25	50
The CD overestimated my knowledge of Immunology	37.5	25	25
This CD provided me with all the information I needed for my course	25	37.5	37.5
I would have preferred an overview of immunology instead of specific details	50	25	25
I was not clear on how the topics fitted into the grand scale of things	50	50	0
I had to supplement this CD to large extent with books	50	25	25
I found the diagrams useful	25	50	25
The diagrams helped me understand the concepts of this subject better	37.5	50	12.5
The diagrams were of good quality	37.5	37.5	12.5
I would have liked quiz questions at the end of each lecture	50	12.5	25

*Pathology and immunology were evaluated separately so that comparisons could be made.

could not readily find specific subtopics. Hence, the development of submenus or search facilities in future versions of this software should represent an improvement in usability.

In general, the level of computer literacy was adequate (Table 4), and from this it can be assumed that there would be few technological barriers to the use of the CD-ROM as a learning tool. The design of a piece of educational software is important, as it must be user friendly and have a level of complexity that matches its end users' ability. It was evident, however, that only 63% of the distance learners had computers at home. Further investigation revealed that those who did not rate the CD very highly tended not to have been able to incorporate it easily into their study habits, mainly as result of not having a computer at home. The immunology section scored poorly relative to the pathology section in terms of content, presentation, screen design/layout and functionality.

Content

Students responded more positively to the layout of the pathology notes. This may have been because the pathology section was written in a style more conducive to distance learning. The pathology section contained three of the five features outlined by King[17] for encouraging cognitiv0e engagement, and these were *Chucking* (grouping or categorisation of information); *Advance organiser* (a bridging strategy between one part of a course and the next); *Rehearsal* (a strategy to promote recall and comprehension).

Chucking was an aspect clearly evident in the pathology section of the application, with information divided into clearly defined categories (grouped mainly by organ type

Table 4. Questionnaire D. Evaluation of users' (n=8) attitudes to and familiarity with computer applications and computers in general. Results are expressed as an average of scores on a five-point Likert Scale (1=Strongly Agree, 5=Strongly Disagree).

	Average scores from Likert scale
I feel confident about formatting a disk	2.6
I feel confident about using the Internet	0.9
I can use new pieces of software quickly and confidently	1.5
I find it easy to access files from the hard drive	1.3
I find it easy to access files from a disk or CD-ROM	1
I need very clear instructions when using a new piece of software	1.4
I enjoy using computer applications	2.1
I don't enjoy reading from a computer screen and prefer to read from a book/notes	2.3
Percentage owning a computer at home	63%

Table 5. Questionnaire C. Evaluation of users' (n=8) rating of the usability of the CD-ROM using five-point Likert scale (1= Most negative descriptor, 5=Most positive descriptor).

Usability descriptors	Pathology*	Immunology *
Ease of use	2.7	2.2
Ease of navigation	1.6	1.5
Screen design	3.4	2.5
Presentation of information	3.4	2.3
Aesthetics	3.8	2.8
Functionality	3.1	2

*1= Difficult to use, 5 = easy to use.

and concept); the aims and objectives of a particular section were outlined clearly at the beginning (advance organiser); and the MCQs at the end of each section were designed to allow the users to test their comprehension and recall (rehearsal).

Students responded positively to the inclusion of MCQs in the pathology section, which they felt helped them with their revision. This preference for MCQs has been demonstrated in previous studies of pathology teaching,[18] and further research shows that MCQs can be used to increase recall and enhance deep learning.[19]

Trends were apparent in the qualitative information supplied. This was particularly evident in the immunology section, many aspects of which the students did not like. Generally, the students found the content, structure and many of the diagrams confusing. One comment highlights this quite well: "In general I found the CD for the pathology helpful, I found the immunology confusing and did not like the approach to the topic, I preferred to study immunology from a book."

Students were not given an introduction to the sections in the immunology module (i.e., their purpose or objectives), but instead were given broad objectives for the course (in line with the face-to-face lecture format). It is possible that this approach is not suited to the distance-learning environment.

Learning outcome

No significant difference was found between continuous assessment or examination marks when the on-campus group was compared with the distance-learning group (Table 6). Although the numbers in the study were small it appears possible to tentatively conclude that students who studied by distance learning (in this subject area) are not disadvantaged. However, distance-learning students scored significantly lower ($P<0.05$) in the haematology module that was taken by attendance in the same semester, compared with those who studied all modules by attendance.

The above results are difficult to interpret as a result of several confounding factors that might have influenced outcomes. For example, students who chose to study by distance learning were a self-selected group and perhaps had a preference for self-directed learning over the traditional lecture format. Ethically, it was not possible to assign students randomly to a mode of study at the beginning of the evaluation.

Scope for improvement

In view of the clear preference for the presentation format used for the pathology section, it was felt that this could form the basis for future designs. Furthermore, qualitative data from users gave more precise indication of areas

Table 6. Comparison of module mark by mode of study.

	Campus group		Distance-learning group		*P* value
	Mean % (n)	SD	Mean % (n)	SD	
Pathology/Immunology					
Delivery mode	Lectures		CD ROM		
Examination	61.7 (6)	19.1	63.7 (17)	8.85	0.77
Continual assessment	74.0 (6)	11.33	61.9 (17)	27.88	0.15
Haematology					
Delivery mode	Lectures		Lectures		
Examination	68.3 (4)	3.77	60.3 (13)	7.39	0.017*
Continual assessment	77.5 (4)	1.9	64.4 (13)	28.8	0.13

that could be improved. One such improvement would be to provide users with past examination questions and tailored feedback on specific areas that were highlighted as confusing. Also, being more explicit on additional reading requirements might improve learning outcomes.

Such improvements could also be applied to the immunology section, making it more systems-based and modular; however, the interrelationship of the different aspects of immunology would need to be highlighted. A pictorial overview (concept map) of the topics covered in the immunology section and the interactions between them would be useful in this context. The positive feedback on MCQs suggests that it would be of benefit to include these in the immunology section.

Conclusions

The increasing need for greater flexibility in biomedical science education is driving an investigation into alternate modes of course material delivery. The aim of the quasi-experimental approach used in this study was to provide greater insight into student attitudes to this approach, while at the same time directing improvements to various aspects of the software used to deliver a pathology/immunology module.

Comparison of the two different approaches to delivery provides direction regarding design, with users displaying a clear preference for a systems-based approach to topics in the course and not one based on on-campus lectures. Final cumulative assessment and examination results demonstrate that learning outcomes in both groups are not significantly different. This indicates that the distance-learning approach to this biomedical topic is, at the very least, as effective as studying on campus. □

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