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In this article, we describe the development of computer-based learning programs for pathology students at Jefferson Medical College. These programs are authored using HTML (HyperText Markup Language), and are available to students on campus and via the internet. Our computer-based learning resources include scheduling information, course goals and objectives, glossary of key words, self-assessment programs and image-based case studies. These educational programs are popular with the students. We recommend the use of World Wide Web technology to improve teaching and learning in pathology education.

Introduction

The computer has become an invaluable tool for medical educators, enabling them to develop improved course materials and high-quality, interactive simulations. Students typically respond favorably to computer-based learning, and there is increasing evidence that computer-based programs are at least as effective in transmitting information as traditional lecture-based presentations (1).

Reasons for the rapid growth of computers in medical education include increased availability of workstations and the rapid growth of software to support information storage and retrieval. Computer-based learning programs enable students to progress at their own pace and provide multimedia resources for an integrated curriculum. Moreover, computer-based learning has the advantage of being easy to update and inexpensive to distribute.

The most significant advancement in the ability to distribute computer-based instructional media has been the World Wide Web (2). Here, we describe the use of Web technology to develop visually-rich, interactive simulations for second-year pathology students. We will take a tour of an online "Virtual Classroom" at Jefferson Medical College and examine the opportunities that our students have for enriching their understanding of pathology.

Materials and Methods

General and Systemic Pathology at Jefferson Medical College, Philadelphia, is a two-semester course taught principally in the form of small group seminars and case study discussion sessions. Each semester includes approximately 12 weeks. Each week is typically devoted to one chapter of the required textbook (3). Students' mastery of key learning objectives and attendance at small group seminars are monitored using 10-question mini-examinations (weekly quizzes) in the extended matching format (4,5).

In 1993, the Office of Academic Computing and the Department of Pathology set out to develop a wide range of educational resources (instructional media) to supplement traditional textbook, lecture and small group teaching. Recognizing the advantages of Web-based distribution on campus, we began converting "stand-alone" computer programs written in HyperCard, Plus and Authorware into Web-based, cross-platform files.

Virtual Classroom

In 1996, exciting new Web pages were developed to replace several layers of menu choices. The metaphor we chose for student access to computer-based learning resources is the Virtual Classroom (Figure 1). This image was designed by a team that included an educational psychologist, instructional designer, information systems representative, artist and a library information specialist.

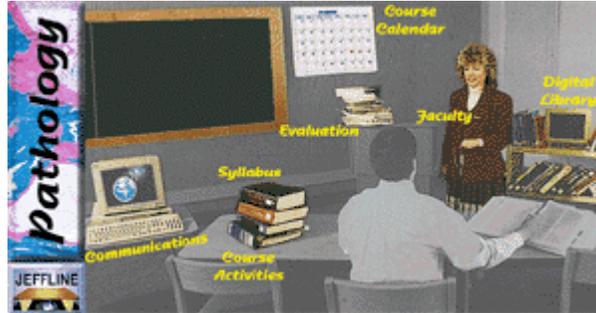


Figure 1. The Virtual Classroom, Thomas Jefferson University

A similar design was created in 1995 for the campus-wide information system, JEFFLINE. This Virtual Office design won several awards, including the American Library Associations "Best Web Site" among college and university libraries.

Within the Virtual Classroom, students can explore a variety of educational resources:

- Communications
- Syllabus
- Course Activities
- Evaluation
- Course Calendar
- Faculty
- Digital Library

Students simply point and click to open these different resources. The major tutorial and self-assessment programs are summarized in Table 1.

Table 1. Computer-Based Learning Programs Available on JEFFLINE	
Course Goals & Objectives	Goals & objectives listed with student generated essay responses
Pathology On-Line	Over 100 clinical case studies covering selected topics in general and systemic pathology
Pathology Glossary	Definitions for over 1,000 key words organized alphabetically and by chapter
Pathology Q&A	Over 3,000 multiple choice questions from previous examinations

Pathology Practical Simulation	Multiple choice questions based on identification of gross and microscopic pathology
Pathology Weekly Quizzes	Interactive extended matching and uncued practical mini-examinations
Pathology Interim Examinations	Practice examinations in the extended matching format

On the following pages, we will follow a Jefferson student as she navigates through the Virtual Classroom to locate information relevant to her pathology curriculum. We will explore the following in sequence: Course Calendar, Digital Library and Evaluation.

Course Calendar

The Course Calendar contains schedules for the lectures and small group seminars. In this example, our student opens the Lecture Schedule to identify an upcoming lecture date, topic, and faculty (Figure 2).

Inside the Virtual Classroom, our student is aided by navigation icons at the top of each page. These icons enable her to move quickly between educational resources. For example, our student might click the Communications icon to access the email system and send a comment or question to her classmates and faculty. At Jefferson, faculty and students find the email system improves teaching and learning by extending discussions beyond the scheduled class time. In addition, students frequently use the email system to exchange information and clear-up misconceptions.



First Teaching Block				
Week	Date	Time	Topic	Faculty
1.	Aug 28	1:00	Science & Practice of Pathology	E. Rubin, F. Gorstein
2.	Sept 3	11:00	Cell Injury	J. Farber
3.	Sept 10	11:00	Inflammation I	R. Rubin
4.	Sept 17	11:00	Inflammation II	R. Rubin
5.	Sept 24	11:00	Principles of Immunopathology	D. Strayer
6.	Oct 1	11:00	Principles of Neoplasia	E. Farber

Figure 2. Pathology Lecture Schedule

Digital Library

The Digital Library contains several popular programs including: Learning Goals and Objectives, Glossary of Keywords, Outline of Pathology and Pathology On-Line (clinical case studies).

In this example, our student accesses the Digital Library to review Learning Goals and Objectives as she prepares for her small group seminar on the topic of cell injury (Figure 3). Each unit contains approximately 30 objectives stated in the form of questions. These questions are frequently posed to the students during their small group sessions.

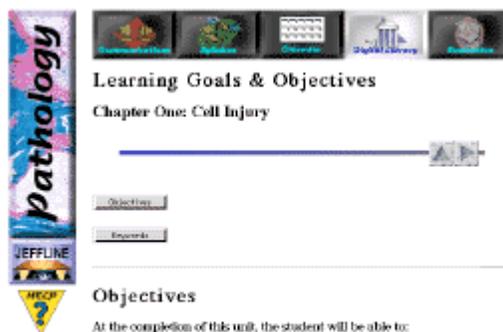


Figure 3. Pathology Learning Goals and Objectives

Next, our student opens Pathology On-Line to preview the images and text that will be presented during her upcoming case study discussion session (Figure 4).

Pathology On-Line contains approximately 100 clinical cases with over 1,000 images of gross and microscopic findings. Students are provided with brief case histories and relevant clinical laboratory data. Questions for group discussion are included at the end of each case. Pathology On-line is used most heavily at the end of the academic year, as students review images in preparation for their final practical examination.

Cell Injury: Page 2 of 3



Look up the definition of this patient's problem in Dorland's or Stedman's. Describe its microscopic appearance. Some authorities have distinguished a "wet" from a "dry" version. Why? What causes this kind of change? What can you do about it?

Figure 4. Pathology On-Line, Cell Injury Case Study

Evaluation

The Evaluation section contains several self-assessment programs, including: Pathology Question and Answer Bank, Pathology Practical Simulation, Interim Examinations and Weekly Quizzes.

Extended-matching quizzes are administered at the end of small group seminars each week. These quizzes motivate students to prepare for class discussion and monitor attendance (4,5). In order to reduce pretest anxiety, the list of matching keywords (potential quiz answers) is released to the class prior to each quiz.

Our experience at Jefferson Medical College indicates that Web-based technology provides an efficient means for organizing and distributing pathology course information. At the present time, our computer-based learning programs do not substitute for traditional lectures or small group teaching. Rather, they provide an alternative learning environment - one that students will use increasingly in the future.

Student response to our computer-based learning programs has been overwhelmingly positive. These programs enable our pathology students to:

- view multi-media presentations
- learn at their own pace
- develop self-directed learning skills
- switch rapidly from one educational program to another
- log-on from off-campus sites, 24 hours a day

In order to learn from our experiment with Web-based instruction, we are tracking log files that record student use. These data will enable us to assess the impact of computer-based learning programs on students' study habits and academic achievement (Frisby et. al., manuscript in preparation). For example, it will be interesting to learn how the computer programs are used by students in relationship to key course objectives. Our preliminary data indicate that the most popular programs are: Pathology Q&A, Pathology Weekly Quizzes, and Pathology On-Line.

An important question that we are beginning to grapple with is whether computer-based teaching should replace traditional methods of pathology instruction. For example, the availability of case studies online has led to a decline in class attendance. Many students believe that their time is better spent working through the case studies online, either individually or in small groups. The risk of moving in this direction is that the faculty lose control and students are required to take responsibility for their own education. On the other hand, self-directed learning is a recognized goal in medical education. Previous studies have demonstrated that students involved in independent study programs have significant advantages over students enrolled in traditional lecture courses (6). More research on this topic is warranted.

URL for Thomas Jefferson University:

<http://www.jefferson.edu>

URL for academic information at TJU:

<http://jeffline.jefferson.edu>

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