Computerized Medical Imaging and Graphics 29 (2005) 223–233

Computerized Medical Imaging and Graphics

www.elsevier.com/locate/compmedimag

Designing high-quality interactive multimedia learning modules

Camillan Huang

Education and Multimedia Applications, Stanford University School of Medicine, SUMMIT @ Wallenberg Hall, 450 Serra Mall, Building 160, Stanford, CA 94305-2055, USA

Received 6 February 2004; revised 25 August 2004; accepted 30 September 2004

Abstract

Modern research has broadened scientific knowledge and revealed the interdisciplinary nature of the sciences. For today's students, this advance translates to learning a more diverse range of concepts, usually in less time, and without supporting resources. Students can benefit from technology-enhanced learning supplements that unify concepts and are delivered on-demand over the Internet. Such supplements, like imaging informatics databases, serve as innovative references for biomedical information, but could improve their interaction interfaces to support learning. With information from these digital datasets, multimedia learning tools can be designed to transform learning into an active process where students can visualize relationships over time, interact with dynamic content, and immediately test their knowledge. This approach bridges knowledge gaps, fosters conceptual understanding, and builds problem-solving and critical thinking skills—all essential components to informatics training for science and medicine. Additional benefits include cost-free access and ease of dissemination over the Internet or CD-ROM. However, current methods for the design of multimedia learning modules are not standardized and lack strong instructional design.

Pressure from administrators at the top and students from the bottom are pushing faculty to use modern technology to address the learning needs and expectations of contemporary students. Yet, faculty lack adequate support and training to adopt this new approach. So how can faculty learn to create educational multimedia materials for their students? This paper provides guidelines on best practices in educational multimedia design, derived from the Virtual Labs Project at Stanford University. The development of a multimedia module consists of five phases: (1) understand the learning problem and the users needs; (2) design the content to harness the enabling technologies; (3) build multimedia materials with web style standards and human factors principles; (4) user testing; (5) Evaluate and improve design.

Keywords: Educational media; Interactive teaching for biology and medicine; Instructional web design; Physiology modules; Multimedia module design

1. Introduction and background

Technology is outpacing us. In the 20th century, technology has become a staple in our everyday lives and has catalyzed innovations in healthcare and biomedical research. This progression has enriched our lives and has brought about the need for imaging informatics databases. However, it has also become difficult for today's student to learn and assimilate the growing amount of content found in these databases (without misconceptions). Technology creates a second problem by changing the expectations of incoming students. Today's students are so surrounded by technology (computers, chat, email, and the web) that it is natural for them to expect coursework to incorporate similar standards. How can we, as teachers, incorporate technology into our teaching so that we can train our students for tomorrow? In turn, how can incorporating technology into our teaching benefit teachers?

2. Teaching: past, present, and future

Traditionally, print textbooks have been the standard reference and learning tool for students. In general, such textbooks are thorough (they cover a large number of topics in detail), well-organized, and incorporate the basics of the life sciences. However, textbooks are static, are not easily customized to different students and classes, and fail to adequately highlight the intersections between different disciplines. Textbooks also cannot provide students with information on the newest scientific breakthroughs since revisions are a major effort and they are costly to students.

0895-6111/$ - see front matter © 2004 Elsevier Ltd. All rights reserved.
doi:10.1016/j.compmedimag.2004.09.017

Informatics can address the need that textbooks cannot provide. Informatics can be used to provide students with up-to-date information that can be disseminated freely through the Internet. A wealth of information datasets can be found in imaging informatics, like computerized tomography (CTs), magnetic resonance imaging (MRIs), functional MRIs, and positron emission tomography (PET) that can be centralized and distributed. Information in these databases may also include simulations and systems modeling. These datasets and patient histories are today's electronic medical encyclopedia and allow interdisciplinary users to integrate, visualize, and cross-reference different studies performed on areas in our body. However, this information often lacks a usable instructional interface necessary to transform the information from a reference tool into a powerful training tool to help students learn.

Educational media, in contrast, can be powerful to train students and is considered the next generation of learning materials. Designed to complement traditional educational methods and information datasets, educational media can supplement core material with animations, interactivity, and visual design. Unlike traditional textbooks, educational media is dynamic, easily customizable, and can be designed with an interdisciplinary approach. It can also be used to teach content in a way traditional teaching materials cannot—for example, animations of mechanisms and processes can help students visualize how biological systems work together. Once taught, interactive media can be used to ensure that students have learned key concepts and understand the basics. In addition, students are more likely to adopt these materials since they are influenced by a world of computers, media, and the Internet.

For teachers, multimedia education can help explain difficult concepts more clearly than a textbook or PowerPoint lecture. When students are able to manipulate experimental factors to see cause-and-effect relationships, they move beyond rote memorization and passive learning to truly understand the material. Educational media can also be designed to correct common misconceptions by targeting difficult or frequently misunderstood concepts.

So what is educational media? There is a trend to move content into the digital medium PowerPoint (Microsoft, Redmond, WA)—but it is still passive and has only limited animation and video support. In addition, many 'interactive modules' contain no more interaction than a click to advance to the next page. True educational media should incorporate dynamic animations, interactivity, and visual design to stimulate, challenge, and test students. The design of a good instructional interface requires an integrated design approach that incorporates best practices from in education, human computer interaction, and instructional technology.

As an example, the Virtual Labs Project, funded by the Howard Hughes Medical Institute, is an initiative to augment the core undergraduate courses in biology at Stanford University. This is achieved by delivering interactive multimedia over the Internet to teach big picture and difficult concepts in physiologic systems (cardiovascular, gastrointestinal, respiratory, renal, vision, cranial nerves, and other mini modules). The concepts in these modules create a foundation not only for the life sciences and medicine, but also for an increasing number of interdisciplines, such as biomedicine, medical informatics, and bioengineering.

For example, if a medical student understands how the kidney produces and concentrates urine, he or she will be better able to understand how diuretic drugs work. A researcher, who learns about the molecular aspects of the concentrating mechanism, could apply this knowledge to understand how sodium influences body fluid maintenance. A bioengineer could apply the same knowledge to design a more efficient kidney dialysis system.

From 2000 to the present, Virtual Labs has tested their interactive multimedia modules on thousands of students in Stanford classrooms and those of our collaborators. And with over 500 pages of development experience, Virtual Labs has developed best practices to aid future module development. These best practices can be applied to any scientific concept.

2.1. How do we create new educational media resources?

Key to the success of the VL modules, and educational media materials, lies in the presentation of information that integrates an appropriate media technique (imaging dataset, technical illustration, animation, interactivity) with best practices in learning (Table 1). In addition, VL emphasizes a user-centric design, that is, we make design decisions based on human factors and match them to the user's needs and expectations. This paper will incorporate these design strategies into a detailed protocol to help guide module development by faculty and a multimedia development team.

When designed correctly, a multimedia module can visually stimulate a student and transform learning into an active, engaging process. A good design [24,25] will allow students to (1) visualize difficult and naturally dynamic concepts, (2) promote active learning, problem-solving, and critical thinking with interactive simulations and virtual environments, (3) interact with the content with

Table 1
The table below lists the pedagogical and human–computer interaction design principles behind Virtual Labs

Design principle	Reference
How people learn	[1–3]
Instructional design and evaluation	[4–10]
Interaction design usability, and human factors	[11–15]
Presentation of information: visual perception, style guides, design strategies	[16–21]
Motivational strategies	[22,23]