Development of Multimedia Computer Applications for Clinical Pharmacy Training

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The development of multimedia computer simulations in clinical pharmacy education enables students to be exposed to clinical patient management earlier in the education process and allows for the training of large numbers of students outside of conventional clinical practice sites. This manuscript describes what multimedia is and how this technology can be applied to clinical pharmacy training. It also discusses the general process for developing multimedia case presentations including hardware and software requirements. Finally, an example of a multimedia case we developed using Multimedia Toolbook® for training pharmacy students in the management of atrial fibrillation is presented. The ease of use of development software, the affordability of the required computer hardware, and the availability of extensive multimedia files on the Internet make it practical for many pharmacy educators to develop clinical multimedia simulations.

INTRODUCTION

There are several factors which make multimedia computer simulations ideal for use in clinical pharmacy education. First, pharmacy students need to be exposed to clinical training earlier in the education process. Second, there is an increasing demand for clinical training secondary to many schools of pharmacy making the transition to an entry-level PharmD curriculum. Third, there is an increasing need for nontraditional methods of clinical instruction.

Pharmacy students often have a difficult time applying didactic learning to actual patient care. Part of the reason is that pharmacy students typically receive "hands on" clinical training only relatively late in the education process. Although it would be beneficial for students to be exposed to actual patient care earlier on, they may have limited access to clinical environments at that time. In addition, at this point in their careers, students often feel intimidated in patient care areas due to their perceived lack of knowledge. Multimedia allows for the simulation of clinical environments early in students' careers and enables them to become comfortable with patient care without worrying about the potential consequences.

There is an increasing demand for clinical training sites for pharmacy students. The current trend among pharmacy schools is to make the PharmD degree the entry level (and therefore sole) degree. In many cases, pharmacy class sizes have not decreased in the process. This obviously creates an increased demand for clinical training since PharmD students typically receive as much as a full year of "practical" clinical training whereas undergraduates receive as little as one month. It will be difficult for pharmacy schools to provide extensive "hands on" experience for such a large number of students. Multimedia allows for an alternative method of providing lifelike clinical training to large numbers of students without increased demands on clinical faculty.

Demand is also increasing for nontraditional methods of providing pharmacy education partly because of the significant numbers of students enrolled in part-time and/or nontraditional PharmD programs. These students typically work full-time and thus require increased flexibility in their coursework. There is also an increasing demand for additional educational experiences among current practitioners who don't have the resources or desire to obtain a PharmD degree, to maintain their competitiveness in the marketplace. Many pharmacists live outside of areas where they could attend traditional university-sponsored courses. Even if they could attend, lectures alone cannot provide the clinical experience they need. In response to these demands, alternative methods of delivering quality PharmD level training to pharmacists need to be explored.

Even during their time spent in clinical settings, students' learning experiences are limited to those diseases present in the patient population at that time. In other words, it's quite possible that during a given five week clinical clerkship a student may not see a patient with atrial fibrillation. Multimedia provides the ability to supplement deficiencies in clinical training by bringing lifelike examples to any student with access to a computer.

There are other inherent advantages of multimedia over traditional teaching methods. Students can stop and restart modules at a later time or repeat material as needed. In addition, there is greater course consistency. The instructor never has a bad day and identical material is offered to each student, every time .

Finally, interactive multimedia offers increased access. The course can be provided over the Internet or on CD-ROM. This provides greater access to education, enables instructors to justify teaching one or two students at a time, and lets students take courses at work, home, or on the road.

In summary, multimedia computer simulations provide numerous advantages in teaching clinical pharmacy. They allow large numbers of students early exposure to clinical practice via computer simulation without increased demands on clinical faculty. They enable students living outside of commuting distance to schools of pharmacy to continue to participate in the education process and allow a certain flexibility in clinical teaching. Since multimedia programs can incorporate pictures, sounds and even full-motion video, realistic simulations of patient care are possible. In addition, multimedia computer simulations provide certain inherent advantages over traditional teaching methods. Students have the opportunity to move at their own pace, choose their own direction through material and repeat material as often as desired.

WHAT IS MULTIMEDIA?

Multimedia refers to the presentation of information in formats other than text alone. Included in these format types are: sounds, images, graphics, animations and videos. The following is an example of how these various formats can be used to more realistically simulate clinical patient cases. In real life, patient information is obtained (and presented) in the following order: chief complaint, history of present illness, past medical history, physical examination, and laboratory tests. The process of obtaining this information involves first interviewing patients, next examining patients, and finally ordering laboratory tests to narrow the diagnosis. Instead of presenting this information as text, as has traditionally been done with clinical pharmacy cases, it can be presented more realistically using multimedia. The patient's chief complaint, history of present illness and past medical history can be presented in the form of a video of a patient interview. Likewise, physical examination findings can be demonstrated using images, sounds, and videos. For example, instead of stating that the patient had a carotid bruit or heart murmur, the actual auscultatory examination findings can be presented in the form of a sound file. The examination techniques of inspection, percussion, and auscultation can all be presented as video, image, and sound files. Unfortunately, at present, there exists no way to represent palpation (or touch) with computer simulation so examination findings of this type still need to be described using text.

Most laboratory test results would still be presented as text, but other findings can be presented in their native formats. Actual electrocardiograms (ECGs) and chest X-rays can be presented along with their interpretations. Although pharmacy students would not typically be required to interpret these, a picture is worth a thousand words, and it is immensely helpful for students to see the irregularity of ECG patterns in a patient with atrial fibrillation or the huge heart on chest X-ray of a congestive heart failure patient.

An additional benefit of interactive multimedia titles presentations is that information does not have to be presented linearly or in any particular sequence; rather, the user can jump around at will to simulate how we typically gather information in real life. This aspect of multimedia is particularly beneficial in teaching pharmacy students about laboratory tests, an area with which they often have difficulty (our experience is that pharmacy students tend to assume that the appropriate laboratory data somehow magically appear on patients' charts). By requiring them to request only the laboratory data they need and then evaluating them on their selection process, it forces students to think about the data's relevance to the care of a particular patient. For example, students might be given the option of selecting arterial blood gases from a menu of labs for a patient with atrial fibrillation. Upon its selection (why else would it be in the case if it wasn't important?) they could be shown the cost and risks associated with obtaining such invasive labs and reminded that, unless it was suspected that the patient was hypoxic or acidotic, this test has no role in the management of atrial fibrillation.

COMPUTER-ASSISTED LEARNING IN HEALTH CARE

Computer-assisted learning has been compared to traditional learning methods in the health sciences in several randomized studies. Friedman et al. compared computer simulations to a "pedagogic" format for case-based instruction of third-year medical students(1). They reported that, although students using the latter format acquired more information, they were less able to utilize the information to manage patients than were students using computer based simulations. Mangione *et al.* compared: (*i*) computer-assisted instruction; (*ii*) small group teaching plus audiotapes; and (*iii*) both, for teaching cardiac auscultation to medical students(2). All students were given a pre- and post-test consisting of audiotaped cardiac events. Students utilizing small group teaching plus audiotapes had a 4.5 percent deterioration in pre- and post-test diagnostic scores, while students utilizing computer-assisted instruction or both had an increase of 7.2 and 3.2 percent, respectively. Finally, Guy and Frisby compared traditional cadaver demonstration labs to interactive-videodisc for teaching gross anatomy to allied-medical-profession undergraduates at Ohio State University(3). They found no significant differences in performance on laboratory practicals, even though students were tested on an actual cadaver. Additional non-randomized studies have demonstrated that computer assisted learning is beneficial in teaching cardiology (medical students), cardiopulmonary resuscitation (allied-health-professionals), and clinical pharmacology (physicians) (4−6).

Table I. Medical images web sites

Title (Description)	Address
Cardiax (cardiology study cases with sounds, videos)	http://www.med.umich.edu/lrc/cardiax/cardiax.html
The Human Visible Project	http:/www.nlm.nih.gov/research/visible/human.html
Jonathan Tward's Multimedia Medical Reference Library	http://www.med-library.com
Pulmonology Images/Cases	http://indy.radiology.uiowa.edu/Providers/ProviderOrgSys/ OSPulmonary.html
Dermatology Images	http://www.uni-erlangen.de/docs/FAU/fakultaet/med/kli/derma/ bilddb/db.html
Neurology Images/Cases	http://count51.med.harvard.edu/AANLIB/home.html
Pediatric Cases	http://www.rad.washington.edu/PedERCaseList.html
Human Anatomy Images	http://www.cc.emory.edu/ANATOMY/Radiology/ Home.Page.MENU.HTML
Medical image teaching files on WWW (list of links to medical images sites)	http://www.si.umich.edu/impact/Fall95/Papers-projects/ Papers/ Scherer/#list

PROCESS FOR DEVELOPING MULTIMEDIA PROGRAMS

All information (images, videos, sounds) to be presented in interactive multimedia titlesprograms must needs to be in digital format to be processed by the computer.

Images

By far, the easiest way to incorporate images (including photographs) into a computer program is to download them as digital files. Table I presents several World Wide Web (WWW) sites that contain medical images in this format. However, if an appropriate image file cannot be located, any picture can be digitized by use of a scanner. Like most computer hardware, the price of scanners has decreased dramatically (to around $300). Also, if only a few images need to be digitized, most copy centers will scan them at a modest cost. If the images are going to be displayed on a computer monitor, they should be scanned at 75 dots per inch (dpi). There is no benefit in scanning at higher resolutions unless one plans to print the images. Also, since most color monitors display 256 colors, the number of colors in the final file should be reduced to this figure. Software such as Adobe PhotoShop® provides such capabilities.

Once scanned, a file format must be chosen to store the resulting image. The most common file format for Windows-based computers is a bitmap (which generally has the file extension BMP), but because of these files' large size and platform dependence, additional formats have been developed. Among the alternate formats are: GIF, JPG, TIF and PCX files (again, these refer to the file extensions). GIF files are limited to 256 colors but are commonly used on WWW pages because of their small sizes. JPEG files (Joint Photographic Experts Group) can represent up to 16.7 million colors and can be compressed to reduce their sizes. These files can be edited using any number of graphics programs such as Microsoft Paint® (which is included with Microsoft Windows®) or Adobe PhotoShop®, the most widely used program of its kind.

Video

Video must also be in digital format to be utilized by a computer. Again, the easiest way to get video into a multimedia presentation is to incorporate an existing digital video file directly. Audio Video Interleaved (AVI), Motion Picture Experts Group (MPEG, or MPG), and QuickTime are among the most common video file formats. While AVI and QuickTime videos are typically one-fourth screen in size and display 15 frames per second, MPEG files can be full-screen and 30 frames per second. Unfortunately, MPEG encoding requires expensive equipment, and requires Pentium-level computers to uncompress the files.

Medical videos are available on the Internet in various file formats or, alternatively, digitized video files can pictures be created by connecting a VCR to a video capture card. Files generated in this manner take up about 27 megabytes (MB) per second of digitized video full-screen and 30 frames per second, the standard used by the television industry). By using compressors/decompressors (codecs) and accepting less than full-screen video, this size can be reduced to under 1 MB per second.

Available hard drives readily store files of this size, but transfer of large files among several co-developers' computers can be problematic. Modem transfer is too slow and floppy disks can store only 1.44 MB of data, so a local area network (LAN) is the most convenient way to transfer files. An alternative to a LAN is the use of removable cartridge drives which plug into a PC's parallel port or which might require more elaborate SCSI (pronounced "Scuzzi") adapter cards, and which can be transported between computers. These drives generally can store 100-250 MB of information on each cartridge.

Audio

Next to text, audio files are the easiest multimedia format to develop. Voice-overs and narration add reinforcement and retention to a multimedia presentation. A microphone (about $10) that allows for direct input of sounds can be attached to any computer that has a sound card. Alternatively, a tape recorder can be used to directly input sound via the sound card's line-in port. There are a number of software packages that can record sounds as digital WAV (pronounced "Wave") files. Depending on the quality of the sound desired, these files also can become rather large. A15 second WAV file at the highest capture quality takes up approximately 1.3 MB, in monaural and double that in stereo. For aesthetic purposes, music can also be added to multimedia programs in the form of WAV or MIDI (Musical Instrument Digital Interface; used exclusively for music) files.

Distributing the Program

Consideration must be given as to how the program, once developed, is going to be distributed. Options for distribution include floppy disks, CD-ROMS, the Internet, or LANs. Although most multimedia development pack-

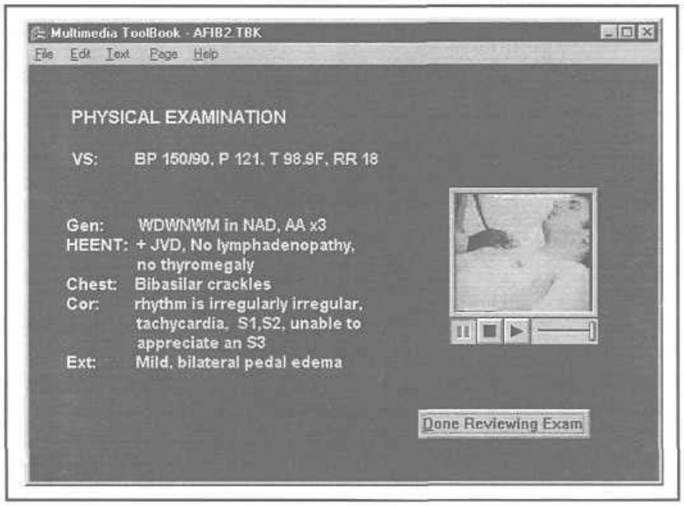

Fig. 1. Sample screen from atrial fibrillation multimedia case.

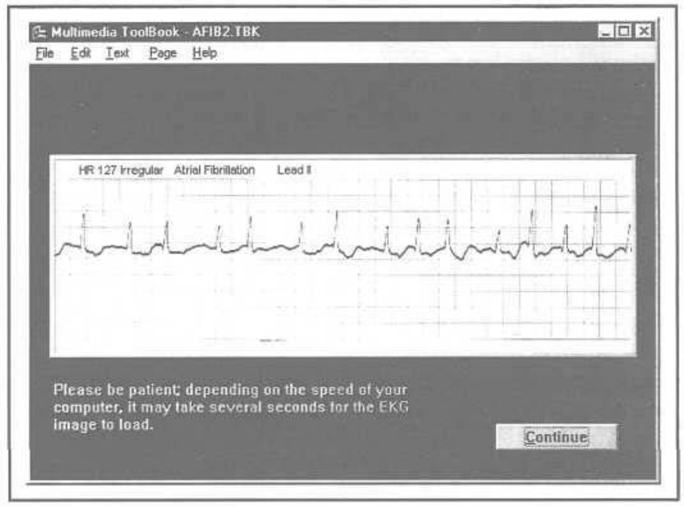

Fig. 2. Sample screen from atrial fibrillation multimedia case.

ages can compress files when creating the final presentation for distribution, if the program is going to be distributed on floppy disks, the number of disks required can be prohibitive. This is especially true if the presentation contains a great deal of video. An alternative medium is a CD-ROM (ROM stands for Read-Only-Memory). CD-ROMs are often used when programs become too large to conveniently distribute on floppy disks. Although a single CD-ROM can hold about 600 MB of information, it can only be written upon using a special writable CD-ROM drive. And, unlike a floppy disk, once a CD is written upon, it cannot be reused. The blank CDs themselves are relatively expensive (around $5) but for rather large programs, the costs involved may be worth it. Duplicating CD-ROMs can cost as little as $1.00 each, depending on volume. During 1997, digital versatile disks (DVDs) have become available. This medium is the same size as CD-ROMs but can ultimately store up to 15 Gigabytes (GB), although the initial DVDs will only store about 4 GB.

If the intended audience is university students enrolled in a course on a campus that has a LAN, then posting the program on the LAN for students to download would be appropriate. However, if the audience consists of pharmacists enrolled in a nontraditional PharmD program or a continuing education course, then different distribution methods would be needed. Under these circumstances, the developers might decide to use floppy disks or CD-ROMs or to post the program on the Internet for downloading by end users, provided it's not too large (8 MB is about the maximum size we would recommend to download over a modem).

HOW WE DEVELOPED OUR PROGRAM

Our particular simulation was designed using Multimedia Toolbook® software, which is quite intuitive and requires little or no programming experience. We developed a multimedia computer simulation that presents a patient case of atrial fibrillation for the student to manage. In developing this program we first had to decide on its purpose: to instruct, to evaluate, or both. This particular multimedia case was designed to be a supplement to didactic lectures on atrial fibrillation and to be both instructive and evaluative. Students are asked to manage a case by first reviewing a patient simulation then answering a series of questions (evaluative). With each answer there is significant information presented regarding why it is right or wrong (instructive). Although we chose not to score their performance, that option is possible. The simulation is interactive, with all pertinent patient data including laboratory tests and electrocardiograms available at the user's request. Information is provided as text (TXT files), sound (WAV files) and full-motion video (AVI files). One of the advantages of multimedia computer programs is that, at any time, the user can review any portion of the case before answering a question. For example, to answer the question "Does this patient have 'lone' atrial fibrillation?" the user must review the past medical history section of the case.

Types of Media Used

We chose to use a brief video of a patient examination in conjunction with text-based descriptions to present exam findings. Actual ECG rhythm strips were presented (with a cardiologist's interpretation and average heart rate printed at the top). We were unable to locate appropriate ECG files on the Internet and so we obtained actual ECGs from patients with atrial fibrillation and scanned them as bitmap files. We used Microsoft Paint® to open the file, adjust the size, and add text (to state the ECG interpretation). Likewise, we could not locate a satisfactory video of a patient examination, so we created our own. A VHS videotape was located which contained appropriate footage. The file was digitized and transferred via the university LAN to the developers: computers.

Distribution

The total size of the multimedia files and program we developed, including the runtime version of Toolbook®, was about 4 MB after compression. Thus, by minimizing the amount of video, we were able to limit the program to three floppy disks.

DESCRIPTION OF MULTIMEDIA TOOLBOOK®

With Toolbook®, no prior knowledge of programming is required to develop multimedia presentations. Basically, a Toolbook® presentation is a series of screens (called pages) which can be linked in any order. Buttons can be added to pages by selecting "Add Button" and then choosing one of several available button types. Once a button is added to a page, actions can be attached to the button by use of "scripts."

Although creating scripts technically involves program-

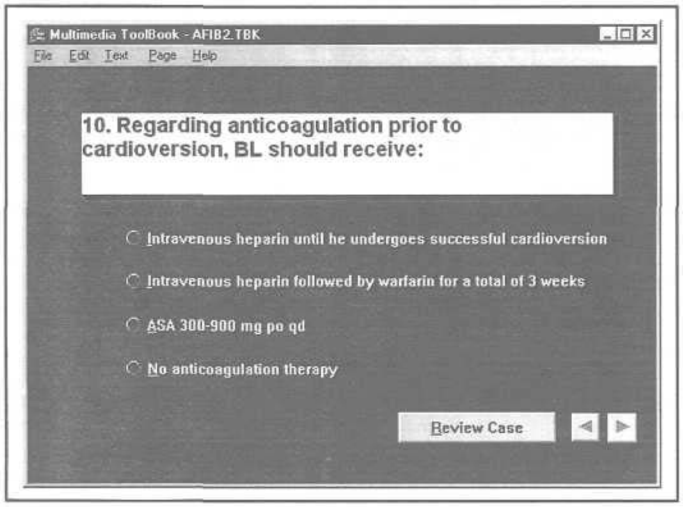

Fig. 3 Sample screen from atrial fibrilllation multimedia case.

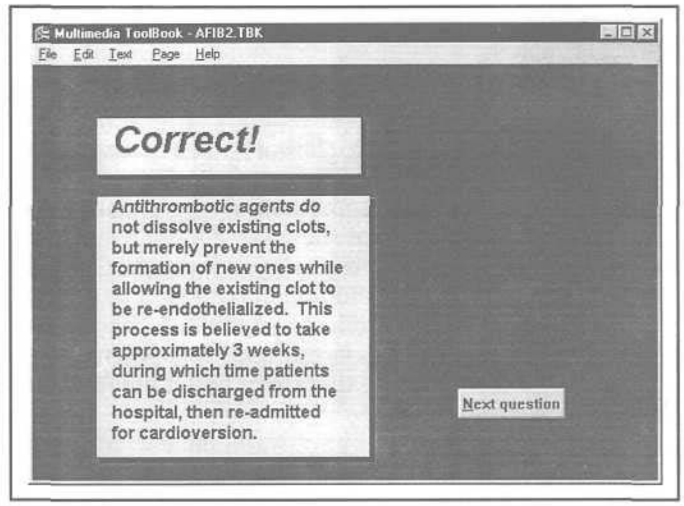

Fig. 4. Sample screen from atrial fibrillation multimedia case.

ming, the command language uses simple English commands such as buttonClick, enterPage, goto, and mmPlay clip (which plays media clips). The generic syntax for Toolbook® scripts is as follows: To Handle <message> <statement>, where the message portion of the command instructs the computer under what circumstances to execute the statement, and the statement portion instructs the computer what to do when the message is received. If, for example, the user is to be taken to a page called "Answer1," when a button is clicked, the following script would be attached to the button: 'To Handle <buttonClick><goto page "Answer1">'. Toolbook® also provides sample generic scripts which can be easily modified.

Scripts can be attached to pages as well as buttons, so that scripts are executed automatically upon entering a page. The syntax for this is similar to that for buttons. For example, to have music start playing when a particular page is opened, the following script would be added to the page: 'To Handle <enterPage><mmPlay clip "music">'. Or, to have an ECG picture automatically display upon entering a page, the following script would be added to the page: 'To Handle <enterPage><mmPlay clip "ECG">'. There are no limits to the number of scripts which can be added to a given button or page.

So our program is merely a series of pages, linked by buttons. Pages contain text, sounds, pictures, or videos which are invoked automatically or upon a button click. Figures 1-4 are sample screens from our multimedia program.

SOFTWARE PACKAGES

There are a number of computer software packages that allow for the development of multimedia presentations, however, they are not inexpensive. Table II presents approximate costs for the software and hardware required to develop multimedia presentations. Asymetrix Toolbook® and Macromedia Authorware® are two of the most widely used programs of this type. Both allow for runtime versions of the program to be distributed with presentations, so the user does not have to purchase a separate copy of the program.

Macromedia Authorware® is icon-based so most of the presentation development can be accomplished with little or no programming. However, as presentations become more complicated, scripting, of the type we discussed with

Table II. Multimedia development requirements and costs

Equipment	Cost
Hardware	
100 MHz or faster Pentium PC (486 machines are acceptable if video does not have to be digitized)	
16 MB RAM (Random Access Memory); 32 MB RAM is preferable if video files need to be digitized using a video capture card.	
1 Gigabyte hard drive	
SVGA Monitor	
Quad speed (4X) or faster CD-ROM drive	
Sound card and speakers	
Microphone	
Modem (33,600 baud) for Internet access	
Total Price (including monitor) for 100 MHz Pentium PC with 16 MB RAM	1,000
Optional Hardware	
Scanner (if pictures need to be digitized)	300
Video Capture Card (if video needs to be digitized)	200
Additional 16 MB RAM	100
Writeable CD-ROM	400
Removable Cartridge Drive (and 100 MB cartridge)	200
Software[a]	
Macromedia Authorware®	1,939
Macromedia Authorware® (academic version)	700
Asymetrix Toolbook®	810

[a]For universities, there are software site licenses available which reduce the cost per user considerably.

Toolbook®, becomes necessary. One advantage of Authorware® is its ability to run the same presentation on both Macintosh® and Intel® platforms, (though this requires both versions of Authorware®). While Toolbook® is also available in Windows® and Macintosh® versions, the same presentation cannot be run on both platforms. Another feature of Authorware® is its ability to track and report user student progress. The program allows the developer to determine how much time a student has spent on a presentation, as well as the percentage of right and wrong answers. The newest version of Asymetrix Toolbook Instructor® offers these same features, but this version of Toolbook® wasn't used for our project.

CONCLUSIONS

The development of multimedia computer simulations in clinical pharmacy has two important advantages: (*i*) it enables students to be exposed to clinical patient management earlier in the educational process, (*ii*) it allows for the clinical training of large numbers of students outside of conventional clinical practice sites. We are not suggesting that computer simulations be employed instead of "hands on" training, but rather that multimedia simulations be used as a means of exposing students to clinical simulations earlier in the educational process and of supplementing clinical experiences, allowing them to be better prepared for actual clinical experiences.

With today's user friendly software, the availability of extensive multimedia files on the Internet, and the affordability of the necessary computer hardware, we would like to encourage all clinical pharmacy educators (though this is certainly applicable to other disciplines) to consider developing multimedia simulations.

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