

MULTIMEDIA APPLICATION ON THE INTERNET

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Background

In August 1995 the National Science Foundation, through SUCCEED (Southeastern University and College Coalition for Engineering Education), funded a project to develop and test a multimedia laboratory experience in work measurement and methods engineering. The primary purpose was to evaluate the efficacy of the multimedia vehicle compared to alternatives such as strictly text-based, standard multimedia, and simulation multimedia (Koelling and Ramsey, 1996).

In August 1996 SUCCEED funded a project to move the aforementioned multimedia experience to the Internet through the World Wide Web. There are many obvious advantages to this distribution media, including ease of update, ease of distribution, version control, and the ability to acquire information on usage. Of course, disadvantages abound. Network traffic, immaturity of software, and other technology issues pose difficulties that must be overcome.

This paper addresses our experience in moving the work measurement and methods engineering multimedia laboratory from the CD to the World Wide Web. The multimedia version was originally developed in Macromedia Director 4.0 (and later moved to Director 5.0) and was made accessible over the Internet by the use of Macromedia's Shockwave technology. We explain issues relevant to moving to the Web and discuss data gathered through the experience in an attempt to compare the CD and Web technologies.

The Multimedia Application

The multimedia system in this research uses a combination of text, video, audio, graphics, and animation to present instructional material. The system was developed with Macromedia Director 4.0 on the Macintosh platform. The projector feature of Director allows each multimedia system to run as a stand-alone application.

The multimedia system presents the material in a highly-structured manner, which has become a standard interface for instructional multimedia. Information is grouped under topics. A button for each topic is present at all times to allow quick access to each section of the program. After a topic button is chosen, the instructional information for the chosen section is presented in a large window. More information about the section can then be accessed through the use of a Next

button, or the information can be reviewed by pressing the Replay button or the Back button. (See Figure 1.)

The multimedia system in this study provides a non-linear (not restricted to sequential discovery), interactive forum allowing the student to choose the pace and content sequence for instruction. The learner can choose a logical route through the instructional material that is meaningful. This may increase the relevance of the material to the student, create a greater motivation to learn, and allow the student to connect and integrate ideas at a conceptual level. A more detailed discussion of the alternative multimedia systems developed can be found in Koelling and Ramsey (1996).

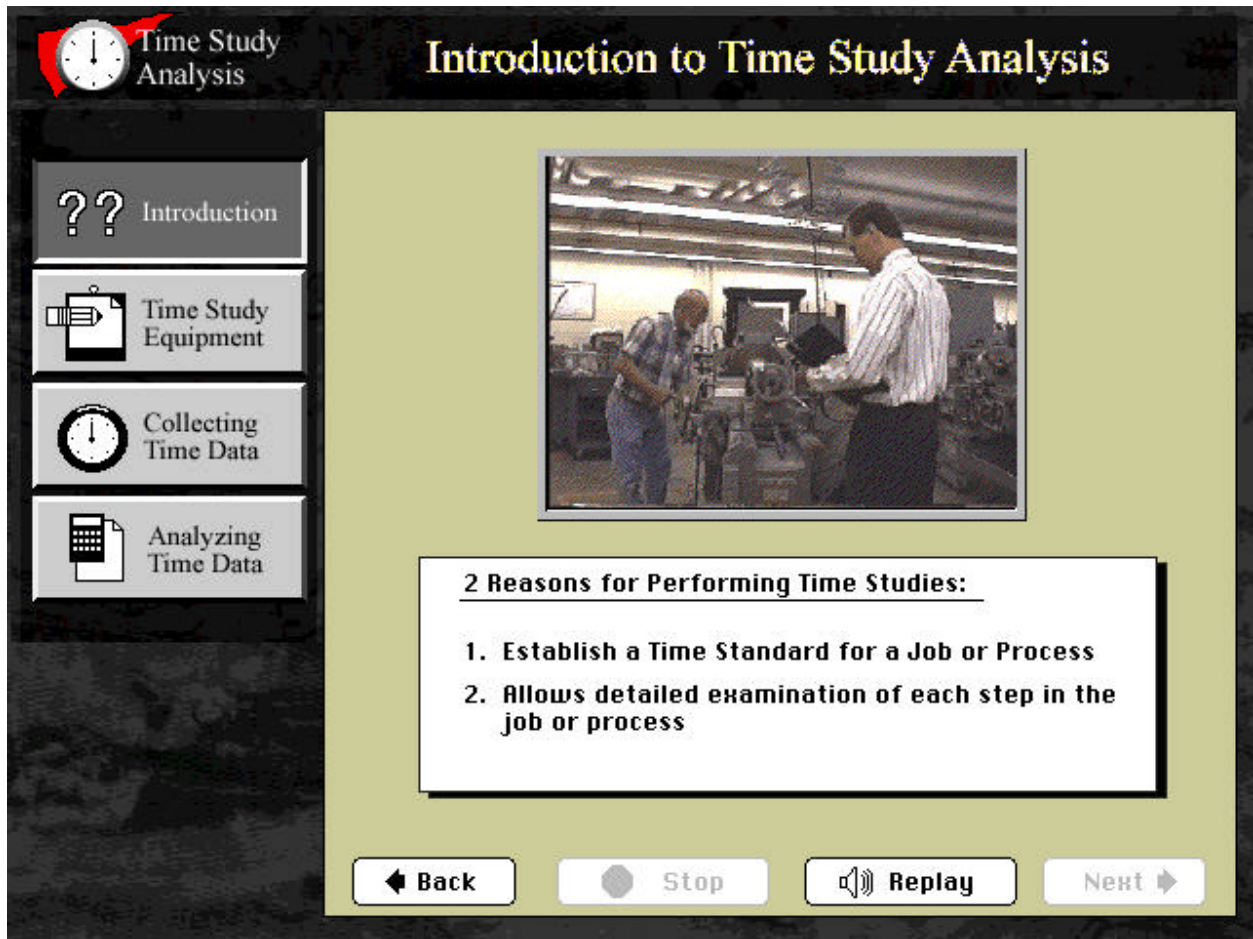


Figure 1. Screen from the multimedia system.

Terminology

The following terminology is used throughout this paper. First, a “movie” is an entire multimedia creation (i.e., it is not equivalent to a video clip). Thus, the entire laboratory is called a movie, and includes sound, videos, text, graphics, and animation. A “cast member” is a bitmap graphic, line of text, video, sound file, menu button, or any other piece of data that becomes part of the movie. Think of the screen (desktop) as a stage, with cast members having their own assigned places on the stage. Finally, a “plug-in” is essentially an add-on language interpreter for your Internet browser. It allows the Shockwave movie to be displayed on the client computer.

Transferring Director Movies to Shockwave

Our initial intent was to transfer, to the extent possible, the entire Director movie (multimedia laboratory) to Shockwave. Due to Shockwave's external file limitations and large download times, however, creating a movie specifically for Shockwave generally produces better results than transferring a Director movie. The various technology components were simply not ready for the entire movie, including video, to be moved to the Web. Our fall-back position was to supply several photos in place of a video, thus saving significant download time and difficulty (more on this later). As opposed to the original multimedia system, the biggest difference in creating a movie specifically for Shockwave is taking event-specific photos to replace the video. Extracting clip art from video frames, as we did, involves opening the video file in an appropriate editing program, such as Adobe Premier, selecting relevant frames and exporting each one as a .PICT file. Each .PICT file is then opened in a photo editing program such as Adobe Photoshop and saved with JPEG compression in order to reduce file sizes. There are several drawbacks to this approach. A lot of the continuity of the video is lost. Also, it is extremely tedious and time consuming. The other elements required to convert to Shockwave were fairly straightforward.

Another key transferring technique was to split the Director movie into several logical pieces and use the HTML code to the fullest extent possible (e.g., start-up buttons generated by HTML code). This reduces the necessary overall cache size, allows the user more control over the downloading procedure, and splits the movie downloading times into more tolerable chunks. Additionally, HTML pages and text download completely into the user's cache directory and are quickly available to the browser screen, whereas plug-in movies require more time to download onto the browser screen.

Creating and Serving a Shockwave Movie

To create a Shockwave movie one creates the movie in Director 5.0 (or greater), saves and compacts the movie, and "burns" the movie using a file compressor called Afterburner. Afterburner can be downloaded as freeware from Macromedia's web site (<http://www.macromedia.com>) and must be installed into the Xtras subdirectory of the Director software. The resulting file is given a .DCR extension and should be placed within the hierarchy of an HTTP server. This file can be incorporated into a web page using the <EMBED> or <OBJECT> HTML tag. To run a Shockwave movie from a server, the server must be configured to recognize appropriate MIME types as would be required with any such system (e.g., Java).

To view a Shockwave movie on a browser, the Director Shockwave Plug-In must be installed on the client machine and the browser must be Shockwave-compatible (Netscape Navigator 2.0 or greater, Internet Explorer 2.0 beta 3 or 3.0, Attachmate's Emissary, Netmanage's WebSurfer).

Shockwave limitations

Shockwave supports external files, such as linked media, videos and external casts. This has the potential for streamlining movies and their downloading time. At present however, the user must

download these files separately from the Shockwave movie and place them in a specific Plug-In support folder before downloading and playing the movie. Viewing the movie is dependent on successfully retrieving the linked files, which now reside on the client machine and must be maintained by the user. Macromedia is currently searching for a means of bundling linked media with the movie.

A user can interact with a Shockwave movie by entering information and observing results but Shockwave does not appear to send information to the user's machine. This is similar to Java's capabilities in that both download an interactive module into the user's browser; the module never actually resides on the client's machine, except in the browser's cache directory. As a result, there is no user maintenance of files and users can't extract data from modules to be saved on their client machines. (This does not include the case of separately downloading external files for a Shockwave movie.)

In particular, video files must be external to Shockwave. Audio (.AIFF) files can be imported into the Shockwave movie but are large and significantly increase the size of the movie. The same is true for clip art saved as .PICT files, although their size can be reduced by saving the .PICT files with JPEG compression. (Note: Director 5.0 will not recognize files saved directly into JPEG format.) The efficiency of using an external cast linked among similar movies, such as one external cast containing all the background items similar among movies, is diminished by Shockwave's external file limitations discussed above (i.e., requiring files to physically reside on the client computer).

All cast members should be in 1 bit or 8 bit color. This means any photo clip art should be created with close attention to minimizing the colors involved. Also, Macromedia suggests remapping colors instead of dithering them when reducing the color bitmap. We did this on everything except the photos, because the quality after remapping was poor and we did not notice a size difference in the resulting cast members.

Photos should be well-planned; taken with concern for using minimal colors while retaining the content-specific intent for including the photos. The relevance of each photo to specific content of the Shockwave movie is important because of the contribution of each picture to the total size of the movie. Downloading time for a movie is proportional to the number of photos in that movie.

Text cast members are smaller and much easier to work with if saved in rich text format (RTF) and not as bitmaps. All of the text in the multimedia system were created as bitmaps. But as each text cast member is fairly small, individual size increases were minimal.

Using Shockwave in a Lab Setting

As discussed in the previous section, creating a movie specifically designed for Shockwave helps ensure that multimedia techniques such as video, audio, and graphics will be used in the most effective manner. From a user's point of view, using a Shockwave movie or a Director projector differs in only two ways. The first is the possible absence of video on a Shockwave movie, due

to the Shockwave limitations on external files. This difference is not necessary, however, provided the system administrator of the client machine is willing to maintain and update these external files.

The second difference is in access time. Because a Shockwave movie must be downloaded over the Internet and interpreted, there may be a larger delay between movie sections using a Shockwave movie than using a Director projector. One solution is to provide an introductory page to the Shockwaved site that uses NETLINGO. NETLINGO is a version of the LINGO programming language created for use over the Internet to manipulate and gain information on files. NETLINGO could be used to create a small Shockwave movie with which the lab administrator can download all the necessary files for the main multimedia application before users begin to access that application. This allows benefits of using the Internet, such as always accessing the most updated versions of the site, but eliminates delay caused by downloading large Shockwave movies. There would still be the smaller delay caused by the Shockwave plug-in.

System Performance

Once the Shockwave movie was created and de-bugged, we measured the operational performance of the system across platforms and compared it with the performance of the CD version. In addition, we measured performance at different times of the day to account for our perceptions of “heavy,” “moderate,” and “light” network traffic. There are many variables we can not control that affect performance (e.g., network load, server load, user equipment capabilities), so the results presented here should be considered preliminary.

Performance Measures

System performance was defined in terms of downloading and running the movie. For purposes of data collection we partitioned the movie into logical, discrete “sections.” Using these sections, we collected data on the time required to access the movie and time to move both between topics and within topics. We define “load” as the computer process of preparing a section for use, such as starting the projector or completing the downloading of a section onto the browser. We categorized network traffic into three degrees of intensity: 8am -11am (Moderate), 11am -6pm (Heavy), 6pm -10pm (Moderate), 10pm -8am (Light).

Timing for the projector version focused on beginning the projector application, accessing the necessary components of each movie section from the CD-ROM, and displaying this section onto the computer. For the Shockwave site, the timing focused on downloading the page from the server, loading the plug-in, and interpreting and displaying contents on the user computer. These measures were acquired for different platforms, at different times of the day, and from different sites (“local” to the server and geographically removed from the server), in addition to the times acquired when using the CD version.

A Note About “Within Movie” Times

Within each section of the movie, sound files govern overall tempo. Because videos in the Director version were replaced with pictures in Shockwave, items may appear on the stage at a slightly different pace during a particular sound clip. However, sound clips take the same amount of time in either version. Other timing differences may be caused by a driver head searching for a file (in the case of external files, such as videos), by author-created differences in the timing (no two authors will create a program in exactly the same way), or by speed and current usage load of the client computer. There is no indication in the available literature that times within movies will vary for otherwise identical Shockwave versus Director versions.

Downloading time—Predicted

“Download-o-matic” is a Shockwave movie made by Macromedia (<http://www.macromedia.com>) that estimates download times for files of a given size. This estimate depends only on the user’s Internet connection speed and does not consider current Internet traffic, possible congestion on client or server machines, or system speeds and configurations.

Using the movie in this research, estimates for downloading time for the Shockwave version are shown in Table 1.

Downloading Time—Actual

Actual downloading times for the sections of the movie, both cached and non-cached, were found using a standard stopwatch, and the results are displayed in Tables 2-4. All times are given in seconds.

Two versions of the Time Study Lab multimedia application were tested on both Macintosh and IBM-compatible computers (Shockwave version only for the latter). The projector, made from Director 5.0, was accessed chiefly from CD-ROM (Table 2). The Shockwave version, also created from Director 5.0, was accessed across the Internet through the on-campus Ethernet network. The internet site was served from a Macintosh Quadra 950 with 24 Mb RAM using WebSTAR 1.3.1 software. The Shockwave version was tested “locally” in both non-cached and cached states (Table 3). Additionally it was tested from a distant location, also through a local Ethernet speed network hub (Table 4).

Table 1: Projected Time (in Secs.) to Load Shockwave Sections, Using "Download-o-matic."

Timing Section & Download Size (Mb)	Internet Connection Type/Speed (kbps)				
	modem			ISDN	T1
	9.6	14.4	28.8	64 or 128	1500
I (0.25)	294	210	102	12	2
II (1.699)	1998	1416	678	60	17
III (0.858)	1008	714	342	42	9
IV (3.366)	3960	2808	1344	120	35
V (2.466)	2904	2052	984	120	25

Table 2: Actual Time (in Secs.) to Load Sections from the Projector.

Computer Model:	Quadra 950	Quadra 950	Power Mac 7100/800	Power Mac 7500/100	Centris 650
CD-ROM Speed:	2X	--	4X	4X	NONE
RAM (Mb):	24	20	16 (+17 vir.)	32 (+1 vir.)	16
Timing Sections:					
I (a)	33.0	15.6	24.0	16.2	30.6
I (b)	5.4	4.8	4.2	3.6	5.4
II	7.2	4.2	4.2	4.2	6.0
III	1.8	1.2	1.2	1.2	3.0
IV	3.0	2.4	3.0	3.0	3.0
V	3.0	2.4	3.0	3.0	3.0
File location:	CD-ROM	main hard drive	CD-ROM	CD-ROM	server via AppleTalk; Traffic Int. -- M

During times of light internet traffic intensity, download times and performance for above computers improved markedly. Additionally, computers with slower processors showed reasonable download performance.

When internet traffic intensity was high, minimum download speeds dropped from around 12 Kb/sec to 4-6 Kb/sec for local internet connections. Minimum download times ranged from 2.5 to 9 minutes per section on the non-server Quadra 950.

It is possible that the load times in Table 4 could be decreased by increasing the cache size of the browser. The cache size used during this data collection was 5 Mb, which means that the cache had to be cleared at least once during each data run.

Table 3: Actual Time (in Secs.) to Load Shockwaved Sections

Computer Model:	Quadra 950	Quadra 950	Power Mac	Power Mac	Pentium	Pentium
	(server)		7100/800	7500/100	90	166
O/S; Software:	Mac7.5.3;	Mac 7.5.5;	Mac7.5.5;	Mac7.5.5;	Win95;	Win95;
	Nav. 3.0	Nav. 3.0.1	Nav. 3.0	Nav. 3.0	Exp13.0	Nav. 3.0.1
RAM (Mb):	24	20	16 (+17 vir.)	32 (+1 vir.)	16	16
NOT CACHED						
Timing Sections:						
I	10.2	10.8	18.0	9.0	18.6	29.4
II (a)	39	160.8	321.0	150.6	68.4	111.0
II (b)	3.6	4.8	6.0	3.0	4.2	36.0
III (a)	25.2	70.2	156.0	112.2	40.8	46.8
III (b)	3	2.4	3.0	1.8	3.6	1.8
IV (a)	64.2	256.2	785.4	318.6	151.8	220.8
IV (b)	2.4	4.2	3.0	3.0	4.2	2.4
V (a)	47.4	222.0	492.0	277.8	111.0	135.6
V (b)	2.4	1.8	6.0	2.4	2.4	2.4
Traffic Intensity:	H	M	M	H	M	M
CACHED						
Timing Sections:						
I	4.8	4.2	7.2	4.2	20.4	2.4
II (a)	30.0	24.0	29.4	11.4	19.2	8.4
II (b)	3.6	4.2	6.6	3.0	3.0	3.0
III (a)	18.6	19.8	16.2	9.0	16.2	6.0
III (b)	2.4	2.4	3.0	1.8	1.8	1.8
IV (a)	46.8	34.2	51.6	16.2	28.8	12.0
IV (b)	3.0	3.6	1.8	3.0	4.2	2.4
V (a)	31.8	28.2	35.4	13.8	26.4	9.6
V (b)	2.4	1.8	5.4	2.4	1.8	1.8
Traffic Intensity:	H	H	H	H	H	H

Table 4: Actual Time (in Secs.) to Load “Shockwaved” Sections from Distant Internet Access (Virginia Tech to Texas Tech).

Computer Model:	Pentium 90					
O/S; Software:	Win95; Nav. Gold 3.0					
RAM (Mb):	40					
Data Trial:	1	2	3	4	5	6
Timing Sections:						
II (a)	300	333	778	399	770	345
III (a)	76	117	408	205	392	163
IV (a)	587	728	3600+ *	759	2009	892
V (a)	493	568	571	808	1025	175
Traffic Intensity:	M	M	H	H	H	H

*Network connection froze after approximately 8-9 minutes with 26% downloaded.

Discussion

The extreme size of the Shockwave plug-ins in this movie create numerous access limitations. The movie sections take too long to download with any commercial grade modem connection (e.g., from 10 minutes to more than an hour). Including video segments in the movie would have greatly exacerbated this problem. Access over an Ethernet connection seems optimal during early morning, evening, or night hours. However, successful downloading is also possible throughout the working day during less busy internet times. Consistent error-free downloading also appears to require the processing speeds provided by Power Mac, Pentium, or top-level Macintosh 68k machines.

Results should improve for projects specifically created as Shockwave plug-ins. Such projects could utilize all the multimedia and interactive tools currently available for Shockwave plug-ins but be designed to specifically account for the technology's size limitations. Furthermore, the Shockwave plug-in technology is only one year old and appears to be evolving rapidly toward overcoming many such limitations by the development of tools that use internet capabilities as efficiently as possible. For example, Macromedia recently released Director 6.0 which supports Streaming Shockwave, enabling users to begin playing a movie before the entire movie has completely downloaded.

Even with pending improvements, it is evident from the data reported here that the Internet is not yet ready to compete with dedicated technology. This work simply demonstrated the feasibility of an on-line laboratory application, and revealed some of the weaknesses.

Summary

Multimedia and the Internet will play an increasingly significant role in the future of industrial engineering education—of this there is no doubt. The pedagogical value it adds depends on many factors. The data reveal that accessible technology is not currently ready to meet the demands placed on it by typical multimedia applications. In addition, development is still difficult and time-consuming, and the reward structure for developing such systems is still evolving. Advances in network speed and software should make such systems useful in the long run and research in these areas is proceeding at a startling rate. It is important for educators to stay abreast of developments and continue to provide challenging learning environments for their students.

The time study application discussed in this paper can be viewed at <http://koelling.ise.vt.edu/shocked/timestdy.html>. You must have the Shockwave plug-in installed to view the application.

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