Using Multimedia to Teach a Class on Technology and Society

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There has been considerable discussion in general educational publications about the value of instructional technology, in particular multimedia- or Web-based instruction. Much of the published work thus far has described various features of multimedia systems in an anecdotal manner rather than focusing on an evaluation of multimedia and its use in the university setting (Windschitl, 1998). In all of the discussion on multimedia, the nature of multimedia and learning using multimedia are interlinked. That is, most authors attribute positive pedagogical implications to multimedia merely because of its nature or structure (Campos, Salcedo, & Rossel, 1996; Fontana, 1993). This perspective combines two aspects of learning, what is learned and how it is learned, into one entity. This pedagogical perspective has some foundation in the literature (Bayne & Land, 2000; Fenley, 1998; Plowman, 1996; Wild & Quinn, 1998). There have been long-standing claims that students learn faster and retain more information the more they are involved in the learning process (Liu & Hsiao, 2001; Royer & Royer, 2002). Therefore, the more students interact, the more they will learn. From a theoretical perspective, Hamilton (1990) saw the curriculum as a process that should not separate what is learned from how it is learned. This duality is the fundamental identity of multimedia.

By its nature, multimedia-based learning is more complex than traditional lecture instruction. According to Mandl (1998), there are a number of factors to consider in designing a model for complex learning. First, there must be appropriate support for complex learning, for example, the development of a multimedia structure by a teacher or peer. Second, there is the need to prepare students for a new learning environment. One major problem with innovative teaching methodologies is that there is a lack of fit between the innovative instruction and the evaluative measures (i.e., tests and examinations). The multimedia and evaluation methods should complement each other and enhance the overall learning environment.

Because of the unique nature of multimedia, problems exist with the delivery of instruction. Jonassen (1991) described three major problems that occur in multimedia: navigation (users get lost in the document), difficulty in integrating the presented information into personal knowledge structures, and cognitive overload. Also, he stated that a learner's interactions within a multimedia environment are not predictable and are less deterministic than other modes of instruction. Other researchers (Babu, Suni, & Rasmussen, 1998; Cordell, 1991) have found that a student's learning style affects achievement on multimedia-based learning. Divergers (using Kolb's learning style preference) were found to improve more on posttest

measures than those who have other learning styles. This could lead one to state that the successful use of hypermedia requires nonlinear thinking on the part of the user—this type of thinking may not be successful for all users.

It is crucial to understand the social aspects of teaching and learning with multimedia. Multimedia and Web-based courses create a different educational environment than is seen in a traditional classroom. Students bring their cultural backgrounds, university expectations, and personal computer experiences into all their learning environments, including the multimedia experience. In class, however, the instructor can adapt to students more easily than in an online environment. In an online environment, the face-to-face interaction is diminished or lost, making it more difficult for the faculty member to interpret the nonverbal cues from the students. This course is taught at San José State University (SJSU), which has an extremely diverse student body. Since learning can not be separated from the learners' historical and cultural backgrounds (O'Loughlin, 1992), this level of diversity provides additional challenges to the use of multimedia in a course.

Design and Development of the Multimedia Modules

As designer of this project, I applied for a SJSU Improvement of Instruction grant and was awarded one for the 1994 calendar year. The course chosen for this project was Technology and Civilization, a general education science-technology-society (STS) course. This course is required for industrial technology majors in the College of Engineering as well as being a popular advanced general education (GE) course for other majors at SJSU.

The GE program at SJSU (1998) is different from many in the United States. Instead of specifying a specific series of courses as part of the GE of each student, SJSU has five core GE areas (skills, science, humanities and arts, social sciences, and human understanding and development). In addition, every SJSU student must take advanced GE courses in four areas: earth and environment; self, society, and equality in the U.S.; culture, civilization, and global understanding; and written communication. Any department may propose a course for any area of GE. The course involved in this multimedia development process was approved as an advanced GE course in the earth and environment area until spring 2000. In fall 2000, after a revision of the university GE program, the course was approved in another advanced GE area (culture, civilization, and global understanding) where it remains an approved course today.

Before any multimedia development work was done, a faculty panel revised the course syllabus. Originally, there were eight units in the course. During the discussions of the course by the faculty, there was a general consensus that there was too much course content. So, the content of the course was revised to reduce the number of units to six. After the course syllabus and content were determined, the development work began on the multimedia modules.

The first decision in the multimedia development process was the choice of authoring environment; the package chosen was Authorware for Windows. In addition, other planning decisions included discussions with the university's central computing facilities related to the use of e-mail by students and the most effective way to manage the e-mail interactions among students and with the faculty coordinator and also determining the best way to include videotaped materials: on videotapes, videodisks, or as a part of the multimedia environment using CD-ROMs.

The primary outcome of this project was self-paced modules on CD-ROMs that allowed students to explore the topics presented in this class on their own, while being able to correspond with other students and faculty by e-mail. Two units were chosen for multimedia development: Unit 1. The Nature of Science and Technology, and Unit 2. Technology and Work. The primary instruction for these modules was by a multimedia-based document that provided an organizational structure for the course. In addition, textbooks, readings, and videotapes were required by the class.

Each unit in the course was developed as a series of files using Authorware, with each unit having an introductory section (file) followed by

four to eight sections (files) in each unit. At the end of each section, students were required to complete a class activity and submit the activity to their professor by e-mail. The individual files were linked by hypertext commands so that the student would not have to run the individual files separately. The multimedia was converted to an executable version for student use. The multimedia modules included graphics, video clips, and animations that were related to the text presented in each section. The media for each section was chosen to build upon the text and was positioned on the same screen. According to researchers (Mayer, 1989; Mayer & Sims, 1994), verbal information and pictorial information are more effective if they are presented nearby rather than on different screens.

The design and development phase of this multimedia course spanned seven years, from June 1994 to May 2001. During this seven-year period, I generated five distinct versions of the multimedia modules. At each stage of the development process, the modules were evaluated by all the faculty teaching the course as well as by students in the course. The significant changes and the evaluation for each version are discussed in the sections below.

Version 1

The first version of Units 1 and 2 was used in fall 1994 and spring 1995 lecture courses as presentation modules although the entire hypermedia course was not finished. The multimedia modules were structured using a modified hierarchical hypermedia. The most significant differences between Unit 1 and Unit 2 at this time relate to their navigational structures. Unit 1, designed first, was predominately linear although some of the sections contained a menu screen. As compared to Unit 1, Unit 2 was less linear in structure and the information was grouped into chunks with page numbers in each chunk.

Selected students and faculty teaching the course evaluated the modules in order to further refine these multimedia documents. In initial field tests with several students, many students reported problems with navigating (getting lost in the document) through the modules. This, according to Jonassen (1991), is one of the three major problems that occur in multimedia. Other feedback was obtained from instructional designers at an international conference in 1996 when I presented the development and design of the first version of these multimedia modules.

Version 2

After gathering several semesters of data on Version 1 of the multimedia documents for Units 1 and 2, Version 2 of the multimedia was created in 1999. Version 2 was a minor revision that focused on the addition of enhancements including a pull-down menu to allow students to end each section in the middle and to return later to where they had left off, a change in font from serif to sanserif to increase readability, and addition of a student log-in subroutine to allow tracking of student pathways through the multimedia.

During the summer session 1999, Version 2 was field tested in one section of the class with 14 students. The students were randomly assigned to two groups: Group 1 completed the multimedia module on Unit 1 (The Nature of Science and Technology) and Group 2 completed the multimedia module on Unit 2 (Technology and Work). The summer session was organized into a one-week class with eight hours of class each day. Day 1 of the class was devoted to Unit 1 and Day 2 of the class was devoted to Unit 2. On their randomly assigned multimedia day, the students were sent to a computer laboratory where each student was assigned a computer and given a CD-ROM. Instead of attending class, they stayed in the computer laboratory and completed the multimedia. In lieu of their "regular" classwork, they completed the online class activities at the end of each section of the multimedia and submitted these to their instructor.

On the first day of class, the students were given a demographic student profile that asked their age, experience and time spent daily on a computer, and major. Also, the students were given two computer attitude questionnaires. The first was an open-ended survey with three questions designed to find out how they defined computers and their love-hate relationship with computers. This survey was developed by Morse and Daiute (1992) and was field tested by this researcher (Backer & Yabu, 1994) in a previous

study. The second survey was a revised version of Oetting's (Martin, 1998) Computer Anxiety Scale (COMPAS). These two computer surveys were given to control for any variability in the computer anxiety and/or attitudes of the two treatment groups.

In addition to the computer anxiety/attitudes surveys, all the students were given pretests for both Units 1 and 2 before either class instruction or multimedia instruction began. On the last day of class, the students were given the posttests for both units. The pretest and posttest for Unit 1 (The Nature of Science and Technology) had eight questions that were selected by faculty teaching the course as representative of the information covered in the unit. The pretest and posttest for Unit 2 (Technology and Work) had 11 questions also selected by faculty.

Students in the two treatment groups had an equivalent mean age (27 years) and similar amounts of time reported as spent on computers each day (3.09 hours/day for Group 1 versus 2.95 hours/day for Group 2). In addition, both groups showed a wide range of computer anxiety on the COMPAS; however, the mean computer anxiety score for each group was equivalent ($M = 108$ for Group 1 versus $M = 107$ for Group 2). In performance, the two treatment groups appeared to be distinctly different. Based upon the ANOVA for Unit 1, there was no difference in student performance when comparing the multimedia-based instruction with the traditional classroom instruction. The students taking the multimedia-based instruction for Unit 1, in fact, did worse on the posttest than those students in the traditional classroom. However, since the students in Group 1 had consistently worse overall performance than students in Group 2, this result is inconclusive. The results from Unit 2 were different than those of Unit 1. The results showed that both groups had significantly higher scores on the posttest than on the pretest. An ANOVA comparing the pre- and posttest scores showed an F value of 39.84 ($p < .001$). As for Unit 1, Group 2 (the students taking the multimedia for Unit 2) performed better on the posttest than did Group 1 although the difference was much less ($M = 7.7$ for Group 1; $M = 8.4$ for Group 2).

Overall, the multimedia for Unit 2 led to higher student achievement than either the "regular" classroom instruction or the multimedia for Unit 1. The qualitative evaluation of the multimedia modules was examined to see if there were any commonalities that indicated why the Unit 2 multimedia was more successful. Ten of the 14 students completed a qualitative evaluation of the multimedia modules. All 10 students liked the multimedia modules for the class. As one student stated, "I liked the video interactions, they allowed me to comprehend the material better." Another student noted, "I found the multimedia portion of this class to be very impressive. I really enjoyed the freedom and convenience of the CD ROM. The content allowed me to gain specific knowledge on specific subjects that I would not have otherwise known about." Overall, the students taking the Unit 1 multimedia found they had a harder time navigating through the material. Since Version 2 of the Unit 1 multimedia presented the material in a linear fashion, the students did not know where they were in the course of the lesson. Also, they noted that it was difficult for them to review previous material. The students who took the Unit 2 multimedia complained about the amount of material in each section.

Version 3

Overall, there appeared to be several issues related to the multimedia modules. Both the Unit 1 and Unit 2 feedback from Version 2 related to two multimedia design issues: navigation and narrative structure. To increase student control of the learning environment, controls were added to all video clips in both Unit 1 and Unit 2 that allowed students to pause, play, and stop videos. Also, each section in Unit 1 and Unit 2 included a class activity at the end so that the students could achieve closure on each topic.

It was evident from the qualitative and student outcomes that the navigational structure of Unit 2 was better than that of Unit 1. However, a problem still existed with the narrative structure. Because the information was not presented in a clear, organized manner, the students' learning was adversely affected. As Laurillard (1998) pointed out in her research, "learners working on interactive media with no clear narrative structure display learning behaviour [sic] that is gen-

erally unfocused and inconclusive" (p. 231). The chunking of information is interlinked with the narrative structure of multimedia. Because the teacher-storyteller is remote from the student-listener, the design of the multimedia and the chunking of its content need to be more robust.

At this time, it was decided to complete a structural change of Unit 2 to address both the issues of chunking and narrative structure before making any substantive revisions to Unit 1. The three sections of Unit 2 were reorganized completely and divided into eight parts: The Industrial Revolution, Industrialization of Society in the 19th Century, Workplace of 1900, Scientific Management, The Development of the Assembly Line, Consumerism in the West, Nature of Work Today, and How Does Technology Affect the Workplace? The content in each section was revised so that the students could reread a section without restarting from the beginning. This reorganization provided a better narrative structure and, at the same time, increased learner control. As Steinberg (1989) found, increasing learner control can make the learning experience more motivating as well as increase student learning.

Version 3 was used in the winter 2001 class as a replacement for the in-class instruction. On the first day of class, the students were given the multimedia CD-ROMs for both units and were asked to complete them at home or in one of the department's computer labs. Each weekday during the winter term, students would e-mail the appropriate class activities to their instructor. A review of the class activities submitted by the students indicated that they learned the subject matter for both units. After the multimedia modules were finished, the students returned to the classroom. Since all the students in the class used the multimedia modules, their performance was compared with a previous winter 1999 class (taught entirely in a "traditional" mode). The winter 2001 class (M = 84), on average, achieved higher grades on the final exam than did the winter 1999 class (M = 78), but the results were not significant. Results from the qualitative evaluation showed no more complaints about navigation or the amount of content in each section for Unit 2 and indicated that the students viewed the experience in a positive light. Overall, the students preferred the navigational design of Unit 2 to that of Unit 1. Overwhelmingly, the comments were positive about the multimedia modules. There was one significant student suggestion for this version of the multimedia. The students wanted the ability to print out the text easily. (Since this multimedia was constructed using Authorware, students could not "cut and paste" the text on the screen as they were accustomed to doing on the Web.)

Versions 4 and 5

Version 4 was the last major revision of these multimedia modules. The work for this revision centered on Unit 1. Based upon the feedback from Version 3, Unit 1 was completely redesigned to follow the "look and feel" and structure of Unit 2. The new Unit 1 was less linear and the information was grouped into chunks with page numbers in each chunk. The existing six parts for Unit 1 were re-divided into seven sections: the old section *What Is Science and Technology?* was divided into two sections: *What Is Science?* and *What Is Technology?* Also, all the video clips for both units were recaptured at higher resolution and converted to QuickTime format in Unit 1. I added a new pull-down menu with an option to view the text in each section as a text file. (This was done to address students' complaint that they could not easily print the text.) Also, the class activities were revised and a few links to Web sites were added. All the movies in both units were changed to allow student use of a standard Quicktime control bar. The multimedia was ported to the Macintosh platform so that students could use either a Windows or MAC computer to view the material.

Beginning in the fall 2000 semester, all instructors in all sections began to use the multimedia modules in their classes. Most of the instructors used the multimedia as self-paced learning while other instructors used the modules as a supplement to in-class discussion sessions. Since all of the instructors used the modules, there was a greater amount of feedback from both the instructors and the students. This dissemination created additional challenges for the instructor and author (who also served as the course coordinator). As Zirkle and Ourand (1999) found, teaching a course through multiple deliv-

VERSION	MAJOR CHANGES
Version 1 November 1994	Six parts: (a) What Is Science and Technology? (b) What Is Scientific and Technological Literacy? (c) The Scientific Method, (d) Attitudes Toward Technology, (e) Technology Dependence and Technology Traps, and (f) Impact of Technology on Society. Each part predominately linear, some contain a menu screen. All sections loop back to the menu screen. Limited student control over videos. Files named numerically. Each part contains a cumulating class activity.
Version 2 August 1999	Minor revision. Same basic structure as Version 1. Added navigation pull-down menus. Changed fonts to sanserif. Added student login to track information. Files given more descriptive names.
Version 3 November 2000	Redesigned color scheme and fonts. Added controls to all videos; controls allow students to pause, play, and stop videos. Redesigned class activities.
Version 4 June 2000	Seven parts: What is Science and Technology? was divided into two sections: What Is Science? and What Is Technology? Completely redesigned the structure to follow the "look" and structure of Unit 2. Less linear, information is grouped into larger chunks with page numbers in each chunk. Added a new pull-down menu with option to view the text in each section as a text file. Revised the class activities and added a few links to Web sites. Revised colors and fonts so that entire unit has a consistent color scheme. Recaptured all video clips at higher resolution and converted to QuickTime format. Changed all movie clips from movie icon to QuickTime media with control bar.
Version 5 May 2001	Minor revision. Same basic structure as Version 4. Revised content of several sections.

ery formats, in this case multimedia as well as lecture, requires new expertise on the part of faculty. During the fall 2000 semester, there were several technical issues that needed to be resolved with various faculty. As faculty experience with the multimedia increased each semester, there were fewer problems and less faculty anxiety about using these modules as an integral part of their class.

The last revision of the multimedia modules, Version 5, was minor and focused on updating and revising the content in several sections. For four semesters, all the faculty currently teaching this course have used the multimedia in their classes. Now, these multimedia modules are required for all sections of this course. There are plans to update the content in each multimedia every two years.

A Worthwhile Effort

The development process of multimedia modules for a GE course at SJSU was very long and complex. In fact, the development cycle of these multimedia modules spanned seven years and five separate revisions. When first proposed in 1994, the process was envisioned as a one-year project. However, there were many twists and turns along the way. Because of the nature of multimedia, there is the expectation that changes in multimedia material will happen frequently. These changes, whether small or large, can be very time consuming. For example, the relatively small change to add a pull-down menu to allow students to print the text (made in Version 4) took six weeks because of the number and size of the multimedia files.

VERSION	MAJOR CHANGES
Version 1 November 1994	Three parts: (a) History of Technology and Work, (b) Nature of Work in the 20th Century, and (c) How Does Technology Affect the Workplace? Each part contains a menu screen. All sections loop back to the menu screen. Less linear, information is grouped into larger chunks with page numbers in each chunk. Navigation pull-down menus. Added student log-in to track information. Files named numerically. Each part contains a cumulating class activity.
Version 2 August 1999	Minor revision. Divided into four parts. The History of Technology and Work section was split into two files: The Industrial Revolution and Industrialization of Society. Same overall content structure as Version 1. Added student log-in to track information. Files given more descriptive names.
Version 3 November 2000	Reorganized completely and divided into eight parts: The Industrial Revolution, Industrialization of Society in the 19th Century, Workplace of 1900, Scientific Management, The Development of the Assembly Line, Consumerism in the West, Nature of Work Today, and How Does Technology Affect the Workplace? Added Previous Section and Next Section buttons to all content chunks (allows students to reread a section without restarting from the beginning). Added more content to the sections. Added controls to all videos; controls allow students to pause, play, and stop videos. Changed font. Redesigned class activities. Added additional video clips. Recaptured all video clips at higher resolution and converted to QuickTime format.
Version 4 June 2000	Minor revision. Added a new pull-down menu with option to view the text in each section as a text file. Revised the class activities and added a few links to Web sites. Revised colors and fonts so that entire unit has a consistent color scheme. Changed all movie clips from movie icon to QuickTime media with control bar.
Version 5 May 2001	Minor revision. Revised content in two sections: Nature of Work Today and How Does Technology Affect the Workplace?

The original development of the first version of the multimedia modules took longer than had been estimated. Also, there was a significant time gap between the publication of Versions 1 and 2. This delay can be attributed to several factors—fatigue with multimedia being the primary one. This factor is infrequently mentioned in the literature. It takes an extraordinary amount of time to develop fully functional multimedia modules. Another cause for the time delay between versions was a university restructuring of the GE program—this multimedia project was put on hold until the class was recertified for GE. A consistent time constraint existed throughout the life of this project. I also work at a teaching institution where the course load is typically four different classes each semester (12 units). This heavy teaching load reduced the amount of time available to work on the multimedia modules during the academic year.

Technical problems constantly occur in multimedia development. And, it seems that often the solution to one technical problem leads to a new one. The story of the video clips in this multimedia project highlight this sort of technical problem. Originally, most of the video clips were captured at 120 X 160 screen resolution in 1994–1995 at 10–15 fps. Then, they were compressed using Digital Video Producer or Adobe Premiere to Microsoft AVI format using Cinepak, Intel Indeo, or Microsoft Video 1 compression. The quality of the video for the time (1994–1995) was fine; but in 1999 I decided that the videos needed to be recaptured at a higher resolution and frame rate. Also, since 1999 there has been an increase in the number of students using the MAC platform; therefore, all the new

recaptured videos had to be converted into Quicktime format so that the video clips could be viewed on both platforms. At the same time, the version of Authorware changed. Version 1 of this multimedia was authored using Authorware 2 while Version 5 was authored using Authorware 5. A new technical problem occurred with Version 4 of the multimedia. On certain Windows platforms (Windows NT, for example), the Quicktime videos would not run. Eventually, this technical problem was resolved by changing the programming in Authorware from a movie icon to a media type. Because of the financial constraints at SJSU, I was forced to allocate time to many programming issues. This time reduced the amount of time available for academic research and development projects.

Since the first version of the multimedia was published, there has been more research that has indicated the importance of good interface design in the context of learning (Maddux, Johnson, & Willis, 1997; Shneiderman, 1997). Brown (2000) called visual and design principles the forgotten partner in multimedia and Web development. As I learned the hard way through the student feedback to Versions 1 and 2, bad design and organization increases confusion in learners and causes them to "get lost."

Most developers of multimedia assume that media-rich technologies help students form a deeper understanding of the material (Bayne & Land, 2000). The qualitative and quantitative evaluations I have conducted over the past few years show that this is almost always the case (Backer, 1995, 2000). The multimedia is "self-paced" and "empowering," to quote two of the students surveyed, but it also behaves in unexpected ways. Students bring their existing worldviews and perspectives to their learning experience, and a multimedia learning environment does not give them the cues they are accustomed to from their professors. This is one reason that this course is a hybrid course rather than a multimedia-only course. A hybrid course balances multimedia instructions with discussion sessions with students. This structure allows the students to interact with each other and the instructor about the content and solves many problems inherent in self-paced instruction including high dropout rate, student lack of focus, and difficulty in integrating the presented information into personal knowledge structures.

Most of the existing research shows that there is no significant difference in student achievement using multimedia as compared to "traditional instruction" (see Russell, 2000, for a review). Therefore, the debate should change to focus on increased access to education. Self-paced multimedia and Web-based courses give more access to more learners. The use of these CD-based modules has allowed students to have more flexibility in completing their GE requirements. In addition, it has allowed the department to serve a larger number of students with less faculty leading to higher FTEs and SFR. This is only one of two advanced GE courses in the College of Engineering at SJSU; therefore, this method of providing instruction provides more options and more flexibility to students in the completion of their GE requirements.

Beyond the effect on the curriculum at SJSU, this mode of delivery provides an opportunity for all STS courses. In this course, these multimedia modules seek to explain the nature and history of technology by using technology. The direct purpose is to provide in-depth course content for all instructors of this course. Indirectly, these modules give students the experience of using advanced technologies to learn about the nature of technology. Although the dichotomy is not directly stated in the multimedia materials, most students comment on the indirect messages about technology and their additional experiences, in this course, with technology as a learning medium.

As more universities consider adding STS courses to their curriculum, the delivery of these courses through multimedia can add depth to the story they are telling about the relation of technology to society. By using the Web and multimedia, student experiences can be enhanced and students can get a richer, more complex view of technology and its effects on our world.

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