Digital Versatile Disc (DVD): The New Medium for Interactive Video

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ABSTRACT

Interactive video has seemed to have significant promise for improving learning in schools since the 1970s but never reached its maximum potential in foreign language instruction. Digital Versatile Disc (DVD) now appears poised to make this potential a reality. After a relatively difficult beginning, DVD videos are being made increasingly available as major producers are starting to commit to this new format. After reviewing technical and legal issues surrounding the use of DVD, the writer describes authoring possibilities that, although initially complex, can simplify the ultimate delivery of interactive video materials to language learners. Finally, he concludes the article by detailing the process of creating a DVD title in a case study at Brigham Young University.

KEYWORDS

Digital Versatile Disc (DVD), Interactive Video (IAV), Foreign Language Movies, Technical Considerations, Authoring

INTRODUCTION

Since the late 1970s interactive video (IAV) instruction has seemed to hold promise for improving learning in schools. Today Digital Versatile Disc (DVD) technology appears poised to make this promise of IAV a reality in education.[1]

To understand the potential of IAV for learning, consider that some 20 years ago individuals with the WICAT Education Institute conducted a study that began in 1979 and that demonstrated that interactive video could play a significant role in education. This study specifically examined videodisc use for teaching freshman biology at a community college as

well as at a four-year university and found that students learned more, in less time, and with significantly better attitudes toward the subject matter (Bunderson, Olsen, Baillio, Lipson, & Fisher, 1981, 1984).

Corroborating those findings with similar results for instructional technology in general, researchers conducting meta-analyses of computer-aided instructional technology (e.g., Kulik cited in Melmed, 1995) have found that students

- usually learn more in classes in which they receive computer-based instruction;
- learn their lessons in less time with computer-based instruction; and
- like their classes more when they receive computer help in them.

The results for interactive video technologies in language study parallel these conclusions, demonstrating effectiveness as an important component of the language learning experience. For example, students at the US Air Force Academy (USAFA) who received instruction via interactive videodisc performed as well on the multiple-choice portion of a posttest as those who received the teacher-based classroom presentation (Crotty, 1984). On the writing portion of the posttest, the students who used the interactive videodisc system outperformed those in the traditional classroom group.

Verano (1987) tested the effectiveness of levels of interactivity using interactive videodisc-based materials. Students who received a passive videodisc presentation preferred learning foreign language from an instructor, while students who used the most highly interactive videodisc-based treatment of the project showed the least preference for learning from an instructor. Furthermore, the students who had the most interactive instructional experience in this study

- were more interested in learning Spanish than the other students;
- felt a stronger desire to visit a Spanish-speaking country; and
- had results that were "dramatically better" than students in the other groups.

In a more recent study at USAFA, Moraco (1996) conducted an experiment that concluded that interactivity with the use of video is a definite boon for improving learning outcome.

Given these impressive results for interactive video technologies, one has to wonder about the level of their use in schools today, in courses in general and foreign language courses in particular. Videodisc, perhaps the

most interactive of video technologies available, is used in many schools, but its penetration is not extensive. For example, data collected by Quality Education Data (1994) demonstrated that usage in high schools increased from 14% in the 1991-92 school year to 34% in 1994-95 (http://www.infomall.org/Showcase/QED/SLIDE11.GIF). However, this increase in no way reflects the potential demonstrated in the research reported above. Furthermore, it is safe to assume that the videodisc implementations reflected in these numbers represent standalone players rather than the interactive videodisc technology investigated in the WICAT study.

Finally, other data unfortunately would seem to indicate that most videodisc usage has been in science and other subjects rather than in foreign language (see Table 1.)

Table 1
Videodisc Usage in Typical Schools

Subject Area	% of Videodisc Use
Science	73.2
Social Studies	64.5
Language Arts	22.6
Library Reference	22.1
Computer Education	19.8
Art	17.1
Reading	14.3
Math	11.7
Music	9.1
Industrial Arts	8.8
Foreign Language	4.1
Business	3.0

Note. From Quality Education Data, 1994.

The data in Table 1 show that 4.1% of the schools surveyed use videodisc in foreign language compared to 73.2% for science and 64.4% in social studies. The only subject area in which videodisc technology was used less than foreign languages was in business.

So what has happened? Why has such an obviously interesting technology not achieved the success in education that might have been expected? It is clear that the lack of acceptance of the technology in the general marketplace has been a key factor. Indeed, videodisc was as good as dead for all practical purposes in 1984 when the ***Wall Street Journal*** and others announced RCA's abandonment of its proprietary videodisc system in April of that year with the headline, "RCA Will Quit Making Players for Videodisks [sic][2]" (Landro, 1984). The spate of bad press represented by this sort of headline did indeed portend serious difficulty for the videodisc segment of the consumer electronics industry, keeping prices higher than

would have otherwise certainly been and precluding the economies of scale that would have been beneficial for school purchases.

Two other contributing difficulties were the complexity of creating interactivity for videodisc delivery systems and the physical size of videodisc players. Although there were classroom uses for videodisc, interaction was mostly made possible with handheld controllers that were not always easy to use.[3] The most interesting interactivity was only possible with a computer that controlled the videodisc player. This mode of operation required the addition of a circuit board in the computer that combined the signal from the videodisc with the computer's graphics image processing for viewing on the computer monitor, an addition that significantly increased the cost of each workstation. In addition to its prohibitive costs, videodisc has suffered from its impractical form factor. The 30 cm disc requires bulky electromechanical components for playback and was destined to require an awkward, space-hogging, add-on peripheral for the computer when used in an interactive configuration.

DVD: OFF TO A SLOW START, BUT QUICKLY GAINING MARKET MOMENTUM

No doubt these difficulties have had an attenuating effect on the adoption of new interactive video technologies in education. Indeed, teachers and lab directors alike lament the rapid changes in delivery systems that seem to never end. Nevertheless, as technological developments have continued, we now see significant promise that they will help IAV fulfill the educational potential promised by the earlier research discussed above. Specifically, DVD technology is now widely available in the consumer marketplace and would seem to hold the key for making IAV available in a broad spectrum of settings. Just as the economies of scale of the digital marketplace have made microcomputers available in greater numbers in homes and schools, so will DVD build on market success and open up possibilities for IAC heretofore unavailable in education.

To understand this bright future of DVD, it is helpful to briefly examine the technology's brief history. Described bluntly, DVD did not get off to a very fast start on the track to success. Indeed, two authors recently described the origin of DVD as being "fraught with as much drama as any good mythology of the gods, complete with elemental forces, colossal battles, and alliances and treachery" (Guenette & Parker, 1997). A good portion of the agitation was based on the entertainment industry's paranoia that their video content would be imminently pilferable in the digital world. The resultant haggling went on for a couple of years, resulting in significant delays in the release of the technology, and was only finally settled with the intervention of representatives of the computer industry.

One of the more serious aspects of early DVD development involved the specialized DVD format, Digital Video Express (Divx), developed by those associated with the chain of Circuit City electronics stores which met with early reluctance by buyers (Olenick, 1999). Recently discontinued as a consumer technology (TechWeb, 1999), Divx was compatible with DVD, but the players were set to play Divx-specific discs for 48 hours only. Although the individual discs were cheaper than regular DVD discs ($4 to $6 vs. $18 to $35, with subsequent 48-hour viewing periods costing about $1 more), the higher cost of the Divx players probably hurt the success of this particular format. Although this chapter is now closed, the presence of Divx undoubtedly caused some confusion among potential buyers.

In another discouraging chapter in DVD's development, early abstainees in investment in the DVD format encouraged many doubters of the technology following DVD's release to the public in the spring of 1997. Missing from early announcements of support for DVD were George Lucas, Disney, and Steven Spielberg, all key figures in the motion picture industry. Although a bit tardy in its arrival, Disney announced on September 4, 1997, that it would release titles in the DVD format (Bush, 1997) but then took several months to release its first titles (***George of the Jungle*** appeared on December 2, 1997, and ***Mary Poppins*** did not appear until March 24, 1998). Probably as a reaction to fear of piracy of their cherished animated assets, Disney has postponed substantial activity in this area, only recently announcing releases in the DVD format (Lieberman, 1999). Disney has published a calendar of many of its popular films to be made available on a one-time basis (at least for the moment) throughout 2000.

Another late adopter has been Steven Spielberg, who has blocked the release of most of his films on DVD (Orwall, 1998). However, DreamWorks SKG finally declared its support of the format on September 24, 1998, with the announcement of the release of three titles (Koenig, 1998).

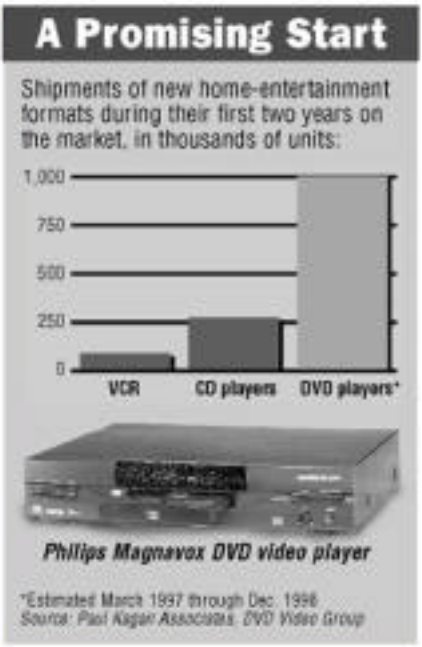
Announcing that the first Star Wars Trilogy would not be released on DVD for the foreseeable future, George Lucas is perhaps the final major holdout for the format, at least partially. His ***Phantom Menace*** is being released on April 4, 2000, but DVD versions of any of the Star Wars series of movies are nowhere in site. Speculation is that Lucas will wait for the installed base of DVD video movies to be large enough to insure maximum earnings from releases.

DVD: INTERACTIVE VIDEO FOR THE FUTURE

Following this slow start, DVD acceptance is now increasing quickly in the marketplace, putting it much further along than VCR or CD-Audio in

their respective developments (Orwall, 1998). As shown in Figure 1, DVD is four times further along than CD-audio and perhaps almost 20 times than VCR in market acceptance two years after their introduction in the marketplace.

Figure 1
Comparison of DVD, CD-Audio, and VCR After Two Years in the Marketplace



Other evidence of market strength is found in the fact that the national video chains Blockbuster and Hollywood Video have been renting DVDs for several months now. Blockbuster began their first efforts in a few stores as a test but then announced at the end of 1999 that they would be making 200 DVD titles available in 3,800 stores nationally by the end of the year as well as 1,000 stores internationally. Furthermore, sources of entertainment media such as Media Play have been consistently increasing their DVD offerings over the past two years.

An additional factor that points out the potential for the success of DVD

is the decision by major game machine manufacturers to include DVD in their game consoles. The first to do so was Sony, which announced this past fall that their PlayStation 2 will contain DVD-ROM drives (http://www.playstation.com/news/ps2.asp; http://www.scea.com/news/press_example.asp?ReleaseID=9537).

A recent announcement from Microsoft adds an additional wrinkle to DVD in the video game landscape as well. The software producer demonstrated on March 10, 2000 what is basically a minimally equipped personal computer that has been optimized for the execution of game software. Not only will the "X-Box," as it has been code named, contain a DVD-ROM drive, it will also have a large hard drive and connectivity to the Internet (http://www.microsoft.com/presspass/features/2000/03-10xbox.asp; http://www.dvdfile.com/news/views/dvd_rom/2000/3_10.htm).

There are several reasons that all of this market activity will improve DVD's chance for success in education, more than was ever possible for videodisc. First, high sales of DVD in the consumer marketplace will have an important positive psychological impact, convincing decision-makers that the technology is significant. This success will create a positive feedback loop in which initial success will bring increased success over time. Second, it is obvious that the expense of any technology has significant impact on its implementation. The increasing availability of DVD will continue to drive costs down through the price reduction of several key components of DVD for the units that would likely be purchased for schools such as laser diodes, digital video decoding circuitry, and disc manufacturing processes, to name but a few.

The final element that will benefit from the market success of DVD has to do with the software for creating DVD applications. The authoring process is quite complex, and the tools necessary for materials development are expensive. With DVD's initial success over the past two years, professional development tools have dropped from a minimum required investment of $250,000 to something less than $50,000. Further drops in price are certain as technological capabilities continue to improve.

Thus, economies of scale, combined with the high consumer interest that is apparent in the marketplace, will create a favorable climate for development for DVD that never existed for interactive videodisc. This climate, combined with the pedagogical benefits of interactive video, virtually assures its implementation in education.

A BRIEF TECHNOLOGY OVERVIEW

DVD is a technology that is similar in many ways to its predecessors, CD-Audio and CD-ROM. Like CD technology, it uses a system of bounc-

ing laser light off the reflective/non-reflective surface of the disc and reading the impulses that are returned to the pickup device. These fluctuations in reflectivity are a result of pits that are engraved on a layer of the disc. The difference between CD and DVD lies in the density of the pits as they are placed on the disc. On a DVD the size and separation between pits are much smaller, yielding a higher density that increases storage of digital information. (For a more detailed discussion of DVD technology, see http://www.howstuffworks.com/dvd.htm.)

To better understand this difference, consider that CDs can store a maximum of 650 megabytes of information while a typical DVD will hold 4,700 megabytes (4.7 gigabytes). Furthermore, a DVD can have two layers on each of its two sides, giving each disc the capacity of 18,800 megabytes (18.8 gigabytes). Assuming a good quality video image compressed using MPEG 2, one DVD disc has a capacity for video of over 133 minutes per layer or almost 4.5 hours on each side. This calculation is based on an assumed data transfer rate off the DVD disc at an average of 4.7 megabits per second (Mpbs), where 3.5 Mbps is used for video, and 1.2 Mbps for three channels of Dolby 5.1 sound (see http://www.dvddemystified.com/dvdfaq.html). Initial manufacturing problems have restricted the number of double-layered discs that have become available, but this situation is rapidly changing.

An important aspect to understand about DVD is that it exists in more than one instantiation. For example, there is DVD-ROM, in which the discs contain digital files much like CD-ROM, of course in significantly higher quantities. In addition, DVD can be DVD Video, basically a consumer-oriented technology that is comprised of discs and affordable playback units. There is also DVD-R (DVD-Recordable), DVD-RAM, DVD-RW and DVD+RW, all competing for DVD technologies that will provide end users the ability to create their own DVD discs. Because of their more widely accepted standardization, this report focuses mainly on DVD Video and DVD-ROM.

The DVD-Video specification entails several capabilities, including various levels of video quality from MPEG 1 at a relatively low bit-rate all the way to MPEG 2 at 10.08 megabits per second, the maximum data transfer rate that is possible with standard DVD drives. Each video title can make use of DVD's capability to handle playback at a varying bit-rate to insure the highest quality playback, even during video sequences that include a great deal of motion. With this approach it is possible to conserve bandwidth during scenes without much motion, thus making compressed digital representation easier. In addition to high quality video, DVD allows for 32 subtitle tracks that are in reality graphical images that the system overlays on the video. The video can also consist of multiple video streams that can be used as multiple camera angles or varying paths through the video, that is, different versions of the video on the DVD such as a PG

version of an R-rated movie. Audio can consist of several tracks that deliver mono, stereo, Dolby AC3 or DTS, or up to eight tracks for multiple languages.

All of these capabilities make a demand on the quantity of digital information that is stored on the DVD disc and transferred during playback. This demand means that the combination of features selected for a given title must fit within the maximum data transfer rate of 10.8 Mbps, with tradeoffs being made for visual quality, audio quality, or other features selected. It is easy to see that titles that use the maximum data rate throughout the video will automatically limit playback time to a little over one hour for a single-layered disc.[4]

DVD CHALLENGES: STANDARDS AND OTHER ISSUES

Some technologists had hoped early on that DVD, being digital, would resolve issues of video compatibility among various video standards such as NTSC, PAL, and SECAM. Unfortunately, the incompatibilities are still present. However, playback on DVD-ROM equipped computers is possible for NTSC or PAL discs. In addition, current model professional DVD players such as the Pioneer DVD-V7400 (http://www.pioneerusa.com/dvd_vplayer.html) and the Philips ProDVD-170 players (http://www.prodvd.philips.com/hardware/dvd.htm; http://www-us.sv.philips.com/news/press/pro-dvd-range_170.html) are both compatible with NTSC and PAL television standards.

DVD has raised a further complicating issue with the institution of DVD Regions for playback. Playback regions consist of six regions worldwide for rights management for DVD content. These regions break down as follows: (a) North America, (b) Japan and Europe, (c) Southeast Asia, (d) Australia, New Zealand, and Central/South America, (e) Northwest Asia and North Africa, and (g) China (Taylor, 1998). Setting the region bits is not obligatory for discs, but rather an option of the content producer and owner. On the other hand, players must be set for particular regions. Although no allowance for multiregion players has been made within the specifications approved by the DVD Forum (http://www.dvdforum.org), individuals around the world are participating in an aggressive campaign to distribute information to make DVD Video players, DVD-ROM drives, and computers as region free as possible. A quick Web search using any search engine will turn up pointers to software patches for computers, ROM substitutes for players (which will void warranties!), and code sequences that use player remote controls to set region codes on particular players.

In addition to issues relating to TV standards and region codes, DVD has also been plagued with a series of format battles that has raised con-

cerns in many quarters regarding the technology's long-term viability. The one assumption that can be taken for granted is that DVD Video and DVD-ROM are now both solid standards. The standard for DVD-R (DVD-Recordable) is also settling down, with the current standard at Version 1.9 and the final Version 2.0 expected in two to three months (http://www.DVDforum.com). When this standard is set, purchasers of the recently released DVR-S201 DVD-Recordable from Pioneer will be required to get a ROM upgrade from the manufacturer, something they have willingly done in other situations as DVD technology has sorted itself out. In the meantime, the 4.7 gigabytes discs created by this recorder are compatible with a wide variety of DVD players. The added capacity makes this particular unit much more useful in DVD authoring than its 3.95 gigabyte predecessor.

The situation for DVD devices that are rewriteable is another matter. Companies are already marketing DVD-RAM, a technology that provides consumers with the ability to create discs that contain 2.4 gigabytes of information. Although DVD-RAM discs were not compatible in first generation DVD-ROM drives, manufacturers have promised compatibility in upcoming versions of DVD-ROM drives (http://www.panasonic.ca/products/datastorage/dvdfaq.htm).

More problematic are the final two proposed DVD Recordable and Rewriteable technologies: DVD-RW and DVD+RW. Neither technology has a commercial version yet, although both have been demonstrated. DVD-RW has been approved by the DVD Forum and DVD-RW is supported by Sony, Philips, Hewlett-Packard, Ricoh, Yamaha, and Mitsubishi, all of which are also DVD Forum members. Although both promise higher capacity than DVD-RAM, RAM's lead in the marketplace will make it tough to beat. (For a discussion of these issues, see http://www.dvdfile.com/news/views/dvd_rom/2000/1_7.htm.)

Illustrating a final issue that garners negative attention for DVD, recent news has focused on the efforts of hackers to remove the copy protection (encryption) system for DVD called Content Scrambling System (CSS). A 15 year-old hacker and his father were recently arrested for publishing information on DeCSS, a system for removing CSS from the files that are stored on a DVD as they are copied to a computer's hard drive (Patrizio, 1999; Widescreen Review, 1999). Efforts by Hollywood to ensure that they maintain control over their assets have continued with recent court actions to keep people from making what Hollywood terms illegal copies of DVDs stating, "Without such copy protection, the motion picture companies would not have allowed their copyrighted motion pictures to be available in this new digital video format. Without motion picture content, there would be no viable market for computer DVD drives and DVD players." (***USA Today***, 1999). The potential impact of recent legal activity is significant, given that the Motion Picture Association of America (MPAA)

and the DVD Copy Control Association (DVD CCA) are not only testing the limits of the Digital Millennium Copyright Act but are also launching a broadside attack on the open-source movement that is supporting development of the Linux operating system, the main purpose for developing DeCSS in the first place. Although the development was mainly to provide DVD support for Linux, defendants are being accused of a wide variety of digital age crimes (Bowman, 2000).

Some knowledgeable sources within the DVD industry, however, are not convinced that such activity is illegal. In a recent editorial, Parker (2000), a well-known consultant and columnist in the DVD world, wrote, "It's time for the music and film industries to abandon their fruitless, costly, and consumer-alienating attempts to rewrite the copyright laws to their own purposes. It's a dead-end, and it's only postponing the inevitable. Make your content widely available, globally compatible, and reasonably priced, and you can eliminate the need and desire to make unauthorized copies. It's the only sensible thing to do." Only time will tell how this aspect of the DVD story will evolve, but it is clear that there is significant interest on the part of all concerned in this exciting technology.

AUTHORING COMPLEXITY FOR DVD VIDEO

Authoring for DVD-Video is a complex process that is substantially different from that used with either videodisc or CD-ROM. This complexity is a function of two major issues. First there is the issue of the many capabilities that make up DVD: functionality such as parental control, up to nine camera angles, eight audio tracks, 32 subtitle tracks, karaoke features, multiple movie versions, widescreen format, and title navigation. Second, there is the issue that these capabilities must be interleaved into a single digital data stream that is to be read from the DVD disc at playback time. During playback, the device on which a DVD is playing must interpret this information and direct it to the appropriate hardware and software locations for decoding. Video information must be sent to the video decoding components, and audio data must make its way to the audio circuitry.

The complexity of this total process dictates that the authoring process must not only be free of defects, but it must also be capable of handling the inherent complexity of the DVD Video stream. Given the need to manage various types of video, audio, and graphical information, developers have many ways to make mistakes, so the system has to check constantly the parameters that are being set. As authoring tools continue to develop, this complexity will become less and less of a problem.

Software to handle this complexity has existed for about three years, but it has been prohibitively expensive for many potential users. Prices for

a combination of MPEG 2 encoding and DVD authoring software started initially in the area of $250,000 for a complete hardware and software system. Prices have dropped in the last year to under $50,000, with entry-level systems falling as low as approximately $5,000.

One of the more expensive components in this system was a drive to create single DVDs for testing the results of a developer's authoring efforts. DVD RAM is now available at reasonable prices, but it is limited in the amount of storage per side. In the single layered version DVD-RAM will hold 2.9 Gigabytes and double that in the double-layered version. DVD-R (DVD-Recordable) has been available for about two years at the prohibitive cost of $17,000 per drive for the DVD, but this first version would only create discs capable of holding 3.95 Gigabytes. Toward the end of 1999 Pioneer released the DVR-S201 DVD-Recordable drive that can write discs with up to 4.7 gigabytes of data storage and yet is also compatible with the same discs that were used on the company's initial system (Bennett, 1999). This system is capable of creating both versions of discs compatible with DVD-ROM drives and DVD-Video players and sells for a suggested retail price of $5,400. Such decreases in price will no doubt continue over the next few years with most experts predicting affordable DVD Recordable units for widespread use by ordinary consumers. Such changes in price and performance will predictably have a significant impact on tools for professional DVD development.

VERSATILITY IN VIDEO

The good thing about the complexity of DVD is that it promises to bring simplicity to the ultimate use of interactive video technology in language learning. For example, homes have VCRs, classrooms have VCRs and maybe videodisc players, and computers have CD-ROM drives. This variety of equipment amounts to three different media of the past that can be replaced with one delivery system, DVD.

Furthermore, DVD not only makes video available in the classroom, but it also is compatible with CD-Audio and CD-Video. Being able to play CD-audio on the same player as video will be a simplifying factor for any classroom that uses authentic audio or video documents. Video CD is a format that has not been commercialized to any great degree in North America, but it is quite popular in other regions of the world. As a result, CD-Video titles are available in languages other than English. DVD can also be interesting for the language learning setting given the fact that today's desktop computers can be used as video development platforms for the creation of Video CD discs that play on DVD players. The decreasing price of CD-R and CD-RW technology has opened up the possibility of editing video that can be shown under simple menu structures. This

approach provides easy and quick access to video in ways not possible with VCRs and videocassettes.

Our recent work has involved filming student teachers on a Sony Hi 8 video camera and using a MicroVideo DH 30 Plus card for encoding the video into motion JPEG. We accomplish the video editing on **Adobe Premiere** running under Windows 98 with the main limiting factor being hard drive space. We recently added a 36 Gigabyte, ultrawide SCSI-2 disk drive that is also quite fast and runs without the recalibration cycles that are typical for IDE drives. This type of drive is important not only for its sheer large capacity, but also because it facilitates capture at a higher quality (S-VHS) than would otherwise be possible. Furthermore, it also ensures the ability to export a video signal directly to videotape when needed.

To create video that is compatible with DVD players, we use the Xing (recently acquired by RealVideo) MPEG 1 encoder and Adaptec's **Video CD Creator** that comes with that company's **Easy CD Creator Deluxe** to create CD-RWs that will play on our Pioneer DVD-V7200 Professional DVD players (see http://www.pioneerusa.com/dvd_vplayer.html). One disappointment that we had to face was that this player does not play materials recorded on CD-R media. Philips' PRODVD 170 will play CD-R (http://www-us.sv.philips.com/prodisc/hardware/dvd170.htm) as will Pioneer's new DVD-V7400 mentioned earlier. The video produced in this way is of acceptable quality for this particular application of filming student teachers. Additionally, as hardware costs come down, it will be possible to produce video using MPEG 2 encoding with a commensurate increase in quality.

Finally, the process of producing desktop video is becoming significantly easier with the advent of affordable digital video (DV) cameras. Using the DV approach, video can be captured directly in digital form onto 8 mm tape and then transmitted using the Firewire (1394) interface directly to the computer for editing.[5] By combining this approach with DVD authoring tools that are already dropping in price, new developers will be able to enter the world of DVD creation.

INTERACTIVE VIDEO-BASED LANGUAGE LEARNING: A CASE STUDY

As can be seen from the specifications and market promise for DVD, the potential for getting students involved in learning language via interactive video is dramatically increased with this new technology. At Brigham Young University we recently completed what is perhaps the first DVD for language learning. Based on the classic Italian film allegory, ***C'eravamo tanto amati*** 'We all loved each other so much,' this DVD title was designed to operate in three separate environments. Created as a nonregion-

coded disc, the title will play in the home on consumer players using a simple menu-based interface, in the classroom using either the menu interface or under barcode control, and finally on a computer equipped with a DVD-ROM with a software interface. The DVD-ROM version will be an offshoot of a current effort to release the title in CD-ROM format.

Authoring the title in order to accomplish the two operating versions of the video is comprised of five main steps:

1. film to digital conversion,
2. subtitle development,
3. interface design,
4. DVD authoring, and
5. teacher's guide.

Film to Digital Conversion

To place the film on video, we obtained a first generation film copy from Technicolor in Rome. After we secured appropriate copyright authorization of course, engineers at the LDS Motion Picture Studios in Provo, Utah, converted the film (24 frames per second) to video (30 frames per second) to a Beta SP video master in a video format compatible with the NTSC television standard used in North America. This master tape was then used for the MPEG 2 encoding that was accomplished using **DVDMaestro** and integrated hardware, both produced by our project partner, Spruce Technologies. Engineers at Spruce used a two-pass encoding approach to ensure a high-quality MPEG 2 data stream. DVD allows for the playback of data streams that were encoded using either Constant Bit Rate (CBR) or Variable Bit Rate (VBR). CBR is the easiest form of encoding, but it requires compromises either in file size of the encoded video or quality of the video image. VBR requires more expertise, more sophisticated hardware and software for encoding, as well as more effort to obtain a desirable end result. Through the use of VBR encoding, the final video image will be of an overall higher quality since scenes that contain a lot of movement will make use of a higher bit rate when required. Scenes with less movement can then be reduced to a lower bit rate to reduce overall storage requirements for a particular title.

Subtitle Development

Also from the original Beta SP video master, the video engineers created a VHS copy with the SMPTE time code in a visible window. Members of

the development team then used this video, digitized as MPEG 1 data files, to determine the locations for chapters (scenes) and subtitles. It was necessary to identify the transcription of each utterance as well as the start and stop points using SMPTE time codes. Using this manual process, student assistants worked from printouts that contained the full script of the movie in Italian along with the English translation. These data files had been prepared during development steps for previous versions of the movie that were produced on videodisc and CD-ROM.

Two types of subtitles were produced: full-text Italian with its English translation and summary subtitles in Italian and English that summarize segments or subscenes of the movie. The summary subtitles are used in two different ways: first in a form in which they appear during the entire segment they summarize and then in a form where they appear only during the first five seconds of the segment. These summary subtitles were prepared primarily to support research into alternative subtitle types. Team members analyzed each scene to determine the various segments. For example, segment divisions were based on characteristics such as simple question and answer exchanges, informative and dramatic dialogue sequences, and even informative monologues. Each of these segments was then analyzed to see how each one contributed to the unfolding of the storyline or contained information important to character development.

Interface Design

The interface for the DVD title is quite simple with an opening screen that gives viewers the option to see two written essays, one on the film and another on the director, or to view the movie. The advantage of this type of simple interface is that the movie is accessible from consumer DVD players using a standard DVD remote controller.

Selecting the "Watch Movie" option from the opening screen takes viewers to a second screen where the desired type of subtitle is selected. Selecting the subtitle then takes viewers to a screen where groups of scenes (chapters) are selectable from a list, identified by scene numbers and representative scene graphics from the first scene in each group. Selecting a group of scenes then takes the viewer to a screen where each scene is represented by a number and a graphic from the scene.

Menus at each level were constructed from graphics that were created by graphics artists at Brigham Young University using **Adobe PhotoShop** for an initial CD-ROM version of the movie. For the preparation of the DVD title, these graphics were modified to a size of 720 x 540 pixels. Then to ensure the highest quality reproduction on typical television screens and to account for pixel distortion during the conversion process, each of these images was "flattened" nonproportionally to 720 x 480 pixels.

To allow for menu-driven interaction using standard DVD remote controls, button masks were created from **PhotoShop** layers for each menu graphic. These masks provide "hot" zones that the DVD players use to provide visual feedback to viewers as buttons are selected during use of the menu-based interface.

DVD Authoring

DVD authoring for this title was a combination of offline and online efforts. Offline efforts centered on the preparation of

- subtitle files,
- menu graphics, and
- video descriptive information.

To facilitate the online authoring process, subtitle files were prepared as described above, using a format that would enable the subtitles to be imported by the authoring system. The authoring software actually uses the text information to create graphic elements similar to graphic files. These graphic elements then make up the "subpicture" information that in essence constitute the subtitles. The disadvantage of this approach is that the textual information is not available in the DVD Video format. The main advantage is that any foreign language can be represented at any location on the screen.

Menu graphics for the user interface were prepared using **PhotoShop** and saved in the JPEG format at the highest possible quality, guaranteeing compatibility with the DVD authoring software. Each graphic had a corresponding two-color mask that identified the areas that were to be menu-selectable and that also provided information for the action state of the button. Video dubs were used to prepare MPEG 1 files for identifying the specific sequences to be used from the video Beta SP master, specifying subtitle "in" and "out" points and listing chapter start and stop points.

Online authoring steps then consisted of importing the various subtitle files, graphics files for menus, button masks for creating selectable zones, and video descriptive information. From the graphics files and button masks, branching information was then added by authoring system operators. For example, each button and scene selection had to be related to the desired action in a fashion that is similar to "conventional" multimedia authoring, except that DVD involves an additional web of information which provides information on the next button to be selected when the directional keys on the remote control are pressed. Another difference between DVD and conventional multimedia authoring is that screens in a DVD title are actually video streams that can be anywhere from one to

many video frames. Button information for branching and menu control is tightly connected to subpictures, the graphics information that also provides the subtitle information mentioned earlier.

Teacher's Guide

To enable movie selections to be randomly accessible under teacher control in the classroom, a ***Teacher's Guide*** was prepared that contains the full Italian text of the movie and is organized into the same chapters used in the computer interface. The guide also contains the SMPTE time code information with which subtitles were placed on the disc, organized into barcodes using Pioneer's Laser Barcode technology. With these codes, a teacher can access any portion of the movie in at most seven seconds. The guide also provides for easy access to the various types of subtitles available on the disc.

The barcodes were created from within Microsoft Excel, but software development is underway that will enable the creation of barcodes within Microsoft Word simply by pressing a control key. This will greatly facilitate the creation of teacher lesson plans for using DVD in the classroom.

Lessons Learned

The development process for this title yielded significant information for future efforts to produce titles of this sort on a larger scale. In particular, the need became clear for a computer-based tool that would control the movie in digital form during the development of all time codes used in the final DVD mastering steps. Some of the needed capabilities exist in the **DVDMaestro** authoring tool from Spruce Technologies, but unfortunately this software is somewhat price-prohibitive at present for doing the sort of steps that were accomplished by student assistants. There is no question that use of the final development hardware and software for DVD authoring would have facilitated development and reduced the number of errors encountered during the preparation of the final digital master, use that will become increasingly possible as hardware and software prices drop. In addition, the development team recognized the need for a barcode tool that would work with the DVD V7200 player to test barcode information as it was finalized. This tool will not be difficult to create, given the RS-232 compatibility of Pioneer's player as well as the availability of Pioneer's Laser Barcode standard on this same player. This technique will allow the barcode information to be tested before actually printing the barcode sheets.

SUMMARY

Despite the fact that research has indicated the value of IAV in language learning, various problems have kept this interesting tool from becoming widely available. Despite challenges of its own, DVD promises to change all this. Market forces will continue to drive DVD hardware and software costs down, opening up tremendous opportunities for educational development. Never before has there been such technology available to the classroom teacher as well as to the individual language learner. Powerful technological capabilities have often been available to the researcher. Now they will also be available to teachers and students via DVD.

APPENDIX

Online Resources

Jim Taylor the author of the popular book, ***DVD Demystified***, has prepared several resources for understanding DVD. First there is a database of frequently asked questions at http://www.dvddemystified.com/dvdfaq.html. He also prepared an online primer on DVD technology available at http://www.zdnet.com/zdtv/callforhelp/products/story/0,3650,2419906,00.html.

For in-depth reporting and information on DVD in the marketplace go to http://www.dvdinsider.com/.

At the center of a lot of attention from the Motion Picture Association of America for publishing information on how to "crack" DVD copies, the site at http://www.dvdutils.com/ is a source for a lot of technical information on DVD. One of the current ***causes célèbres*** of the site is the promotion of software to defeat the region codes that are part of DVD technology.

The DVD Forum maintains a Web site that contains up-to-date information on this group's efforts to promote DVD technology (http://www.dvdforum.com).

Another site that contains a wealth of information on DVD technology in general can be found at http://www.dvdfile.com/.

Online Sources to Rent DVDs

Consumers can rent DVDs at NetFlix.com (http://www.netflix.com/). Customers can order movies online and receive them in two to three days. They can keep them a week and then return the discs in the prepaid mailers shipped with the discs. Netflix.com has a fair collection of foreign language movies.

Online Sources to Buy DVDs

Amazon.com has an excellent collection of DVDs, including the title mentioned in this article, ***C'eravamo tanto amati*** 'We all loved each other so much.'

DVD.com (also Express.com and formerly DVDExpress.com) has a large selection of foreign language DVD titles.

Miscellaneous Resources

The DVD Forum
http://www.dvdforum.com/

Spruce Technologies (Advanced DVD Authoring—Windows NT-based)
Spruce Technologies, Inc.
1054 S. De Anza Blvd. Suite 200
San Jose, CA 95129
Phone: 888/355-MPEG
E-mail: info@spruce-tech.com
WWW: http://www.spruce-tech.com/

Sonic Solutions (Advanced DVD Authoring—Macintosh-based)
Sonic Solutions, Inc.
101 Rowland Way
Novato, CA 94945
Phone: 415/893-8000
Fax: 415/893-8008
E-mail: info@sonic.com
WWW: http://www.sonicsolutions.com

NOTES

[1] Although at the outset, DVD supposedly stood for Digital Video Disc, the official definition is now Digital Versatile Disc, a term that is understandable in light of the DVD Forum's recent announcement of the new DVD audio standard (http://www.dvdforum.com).

[2] It is interesting to note that the print media has insisted on spelling the words, videodisc and compact disc, with a "k" rather than a "c," as is done by manufacturers and developers of the technology. Just recently, however, the New York Times revised its style guide, indicating that words related to optical media such as "videodisc" and "compact disc" should be spelled with a "c" instead of a "k" (Parker, 1999).

[3] The significant exception to this problem is the use of barcode technology that has been carried over by Pioneer to their industrial DVD player, the Pioneer DVD-V7200.

[4] The reader should remember that an average data rate of 4.7 Mbps is used to calculate the capacity of 133 minutes per layer cited above.

[5] The Firewire, or ISO 1394 interface, was invented by Apple computer and is being widely adopted by the consumer electronics industry. It is quite fast but unfortunately is not gaining much acceptance in the Wintel world, which is focusing its attention on Universal Serial Bus (USB).

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