Perspectives on multimedia systems in education

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Although multimedia or interactive video seemed revolutionary in the early and mid-1980s, its application to individualized instruction followed clearly defined evolutionary paths. Forms of individualized instruction leading up to multimedia instruction are described, and a review of the integration of individualized instruction into a standard education curriculum is included. Discussed is a jointly defined effort between IBM and the California State University at Fullerton that demonstrated: (1) the benefits of a parallel course-development and course-implementation approach, (2) the superiority of multimedia over traditional instruction in the subject area tested, and (3) very low-cost development of quality multimedia courses. A projection by IBM for its own internal education program indicates that by the year 2000 not only will individualized instruction become fully integrated into IBM's education curriculum, but it will become the dominant approach, encompassing within it many aspects of traditional instruction. The continuing integration of individualized instruction with other technologies and advances in digital full-motion capabilities can help make multimedia instruction not only independent of time and place, but more engrossing and enjoyable as well.

In the early and mid-1980s, multimedia technology, composed of computer-controlled motion video sequences, one or two channels of audio, touch-sensitive display screens, and graphics overlaid on video, seemed like a revolutionary advance in education technology. This paper attempts to place this technology in an evolutionary rather than revolutionary perspective with regard to individualized instruction. Relative to this perspective, we describe some results in course development and course implementation achieved in a modest, jointly defined effort between IBM and the California State University at Fullerton, California. We also examine the influence of hypermedia on multimedia instruction and look at the direction of IBM's use of individualized instruction for its internal education program. This paper is not intended to describe the newest technologies in multimedia systems but rather to review how multimedia instruction has been used and some of its potential.

Individualized instruction makes use of a variety of technologies, from simple teaching machines to computer-controlled multimedia systems. However, the key issue of individualized instruction in both academic education and industrial training for the last 40 years has had nothing to do with a specific technology. This issue is the integration of individualized instruction into the so-called "standard" education curriculum. We discuss the effect of this issue on use of multimedia instruction in education.

Forms of individualized instruction

Since the 1950s, individualized instruction has primarily taken the forms of self-study, programmed instruction, computer-assisted instruction, computer-managed instruction, and multimedia instruction. (Some common synonyms for multimedia instruction are interactive video, computer-based interactive video, and Level III interactive video.) All these methods are characterized by self-pacing: the student proceeds through the instructional material at his or her own rate.

Interactive video achieved the compactness necessary for a practicable multimedia system.

Self-study. "Self-study" seems to exist at the edge of formal educational respectability. However, it is still widely used. Self-study materials are closest in form to the textbook. Generally, they are in print form, divided into chapter-sized segments, with a set of questions or problems or both at the end of each segment. Recommended suggested answers are also normally included. Hence, the delivery medium is printed text, input is written constructed responses or choices, and an analysis of responses is performed by the student.

Programmed instruction. Programmed instruction (the delivery technique rather than the development method) tends to be highly structured and requires frequent responses from the student. Programmed instruction (PI) provides immediate feedback to these responses.[1] It may or may not use a branching technique. Branching enables the student to bypass portions of the material based on his or her responses to criterion questions. Although programmed instruction can be applied to a wide range of delivery media, the most common has been printed text. Input to PI materials consists of written constructed responses or choices, and analysis of responses is performed by the student.

Computer-assisted instruction. In the mid-1960s, around the time that Marshall McLuhan first promulgated the notion that ". . . the 'content' of any medium is always another medium,"[2] computer-assisted instruction (CAI) authors were busily developing and adapting behavioristic programmed instruction materials for the computer. Both programmed instruction and self-study materials, as delivered by the computer, became known as the tutorial mode of CAI. But CAI was not limited to "electronic page turning," as some critics charged. CAI gave course developers the ability to handle a wide range of input from students, use sophisticated branching techniques, and adapt instructional materials to the learning styles of individual students. For many, cognitive modes of CAI, such as problem-solving and simulation, were more appealing than the tutorial approach.

The primary delivery medium for CAI is the display screen. Input to a CAI course consists of constructed responses or choices entered via a keyboard, and analysis of responses is performed by a computer.

Computer-managed instruction. An extension of CAI, computer-managed instruction (CMI), provided the link between CAI and multimedia instruction. The premise of CMI was that the primary role of the computer in individualized instruction should center on what computers are inherently good at: analyzing large quantities of data. Thus, computers should be used primarily for testing and prescription rather than instruction itself. In this framework, students would take criterion tests on the computer system, and the prescription by the CMI system might be: "Based on the results of your test, you should now view this filmstrip or hear this audio tape." CMI seemed more economically friendly than CAI, since existing materials in other media could now be used under the managing aegis of the computer. The problem was that the entire individualized instruction "system," rather than becoming more compact, became more dispersed.

Multimedia instruction. Whereas CMI indicated the need for multiple media in individualized instruction, interactive video achieved the compactness necessary for a practicable multimedia system. Ironically, this compacting process may, in the future, de-emphasize the use of the videodisc, as current developments such as Digital Video Interactive (DVI™) and advances in animation suggest.

The technology behind multimedia instruction is the hybridization of the microcomputer and

Table 1 Evolution of various media in individualized instruction

Generic	Specific Traditional	Specific CAI/CMI	Specific Multimedia
Motion images	Filmstrips	Filmstrips (via CMI)	Video
Still images	Slides	Computer-displayed graphics	Video, computer-displayed graphics
Voice	Lecture Audio tapes	Audio tapes (via CMI)	Audio (from videodisc) Digitized speech
Text	Books	Computer-displayed text	Computer-displayed text

the videodisc player. Instructional video went through its own evolution of linear video (referred to as Level I) and basic branching video (Level II). In the latter, data for programmed stops and branching based on choices made by the student via remote-control keypad are recorded on the videodisc. Logic in the videodisc player analyzes the information entered by the student through the keypad and causes "branches" to the appropriate audio and video sequence.

Touch-sensitive screens gave the multimedia system an additional input medium. The delivery medium for multimedia is a display device capable of showing both text and graphics from the microcomputer system, displaying still and motion images from a videodisc player, and playing one or two channels of audio from a videodisc player. Some systems, such as the IBM 4055 InfoWindow® Touch Screen Color Display, can overlay text and graphics onto video images. Input media are the touch-sensitive screen, the keyboard, and the mouse, and analyses of responses are performed by the microcomputer.

To illustrate the evolution of media used in individualized instruction, Table 1 lists some generic media in education and specific examples used in traditional, CAI or CMI, and multimedia instruction. Figure 1 shows a screen from the recently released "Mammals: A Multimedia Encyclopedia," developed by IBM and the National Geographic Society. This application integrates different media such as motion images, still images for animal photographs and maps, text, and digitized sound for narratives and animal vocalizations. The program also uses techniques such as an animal classification game and a hypertext method for cross-referencing information.

Some significant characteristics of the transition from CAI or CMI to multimedia are:

- Increased use of pictorial and audio material
- Compaction of the "system"
- Integration of instruction with other applications
- Increased learner control
- Use of the touch-sensitive screen for input
- Increased use of simulation and problem-solving modes
- Authoring and presentation systems as media managers

We now elaborate on these characteristics.

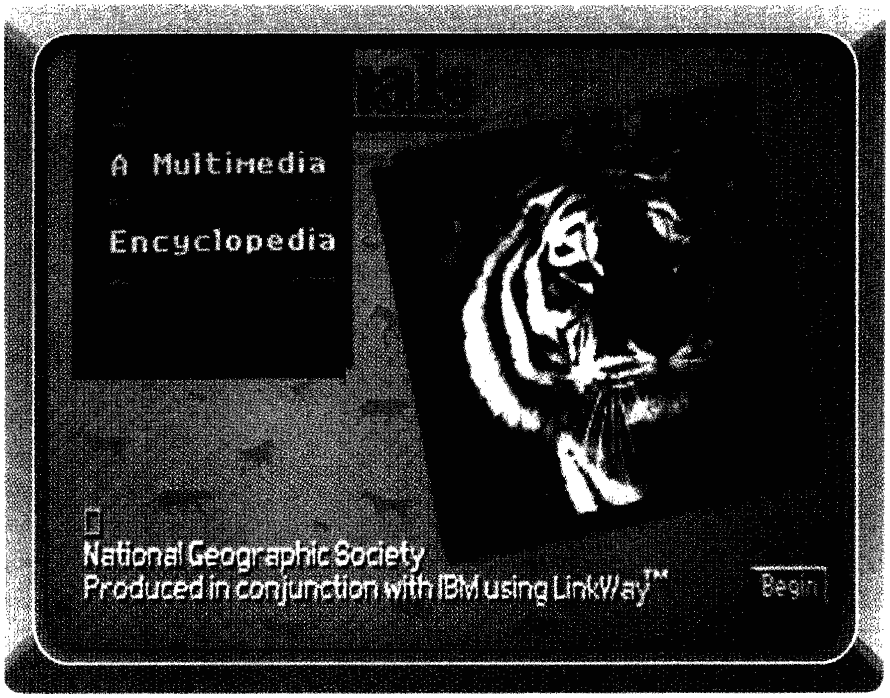
Increased use of pictorial and audio material. Just as self-study and programmed instruction materials were adapted to run on CAI systems, course developers adapted existing CAI or CMI, linear video (Level I), and branching video (Level II) course materials for delivery by multimedia systems. Multimedia courses tend to use less text than CAI or CMI courses; text is replaced by audio, still and motion video, and graphics.

Compaction of the "system." Computer-managed instruction generally utilized a separate workstation for each medium. Media such as filmstrips could require a separate room. Multimedia significantly compacts this system.

Figure 2 shows a full configuration of the IBM 4055 InfoWindow system used for individualized instruction. (The IBM 3363 Optical Disk Drive, used to store a curriculum of courses, and the second videodisc player are optional.) All media are delivered via a single display, which has the additional capability of mixing the media (such as overlaying text and graphics on video). The sample screen shown is from the adult literacy course, "IBM InfoCourse: Principle of the Alphabet Literacy System," by Dr. John Henry Martin of JHM Corporation.

Integration of instruction with other applications. The evolution of IBM's instructional systems illustrates the integration of the instructional application into the mainstream of data processing.

Figure 1 Screen image from a multimedia encyclopedia



Screen image © Joseph M. Bailey, National Geographic Society

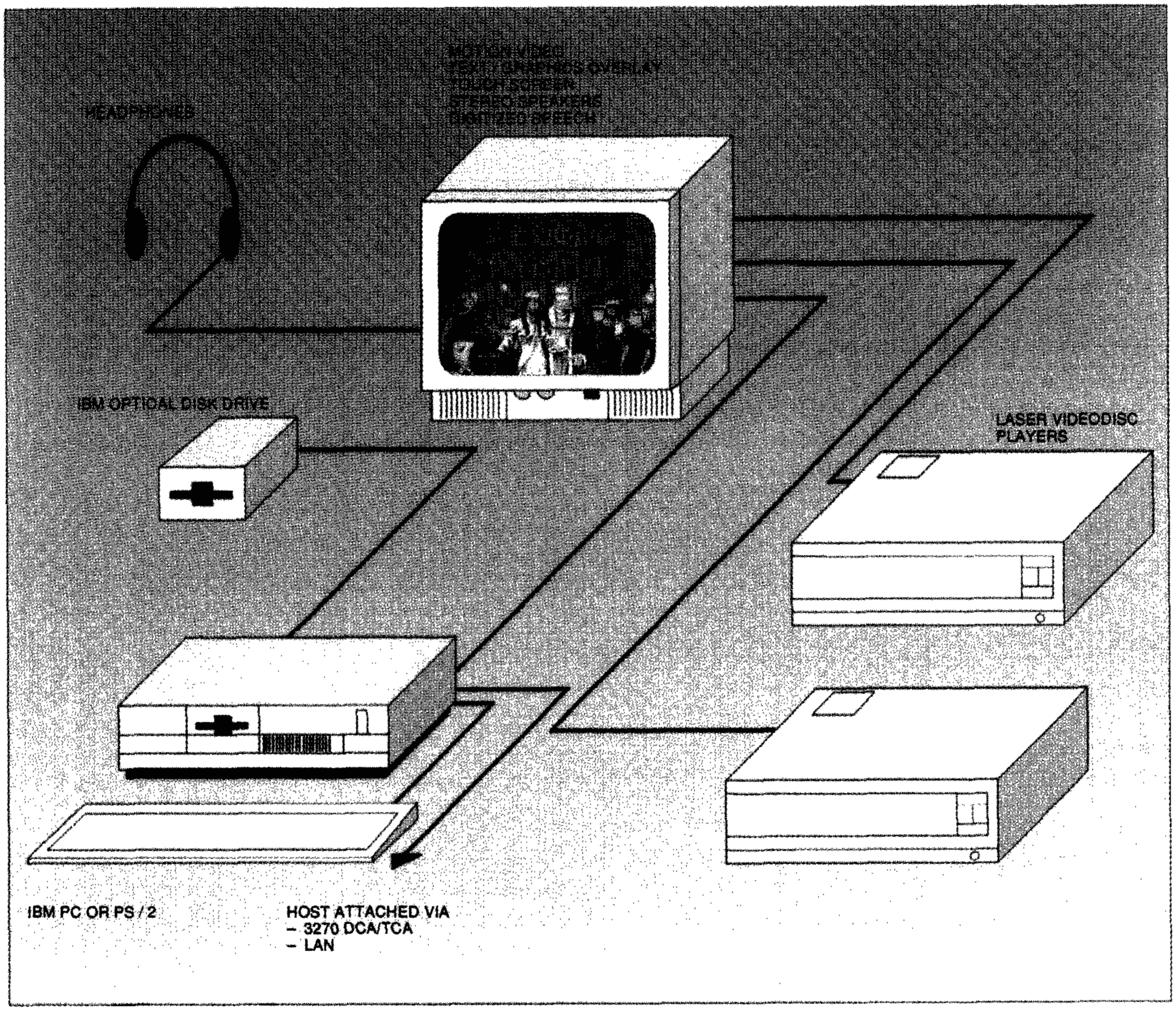
The IBM 1500 system was a special-purpose design, quite sophisticated for its time. Dedicated to education, it contained an early version of Coursewriter, IBM's instructional development and delivery software. However, two succeeding versions of IBM's instructional software, Coursewriter III and the Interactive Training System (ITS), became time-shared, host-based applications on the System/360™. In 1977, Coursewriter III and ITS were combined into one system, the Interactive Instructional System (IIS), supporting eight different mainstream operating systems.

The transition of individualized instruction from host-based systems to stand-alone personal-computer-based systems in the 1980s did not stop this integration process. The InfoWindow system (see Figure 2) can operate just as a personal computer, if desired. Most multimedia systems are designed to provide product information via either a controlled presentation or stand-alone, public access mode. Figure 3 shows the InfoWindow system with devices that can be attached to assist in these modes. The sample screen shown is from the "Exploring the InfoWindow System" presentation.

The M-Motion Video Adapter/A™, announced by IBM in February 1990 for Personal System/2® (PS/2®) computers using Micro Channel® architecture, takes this integration process one step further. The IBM 4055 InfoWindow Touch Screen Color Display contains its own video adapter card. However, the M-Motion Video Adapter/A, which is inserted into the system unit of a Micro Channel PS/2 computer, provides interactive, full-motion, windowed video on a variety of monitors. The M-Motion adapter also provides still-frame video capture, audio recording and playback, and various other audio and video functions.

Increased learner control. If you mentioned "learner control" to a course author during the transition of PI to CAI, the author might assume you were referring to one of the then-perceived advantages of CAI: preventing the student from seeing the answer to a criterion question. The interpretation of this term has now changed to denote a set of functions that enables individual students to take a course in the manner most comfortable to them.

Figure 2 IBM 4055 InfoWindow system for individualized instruction

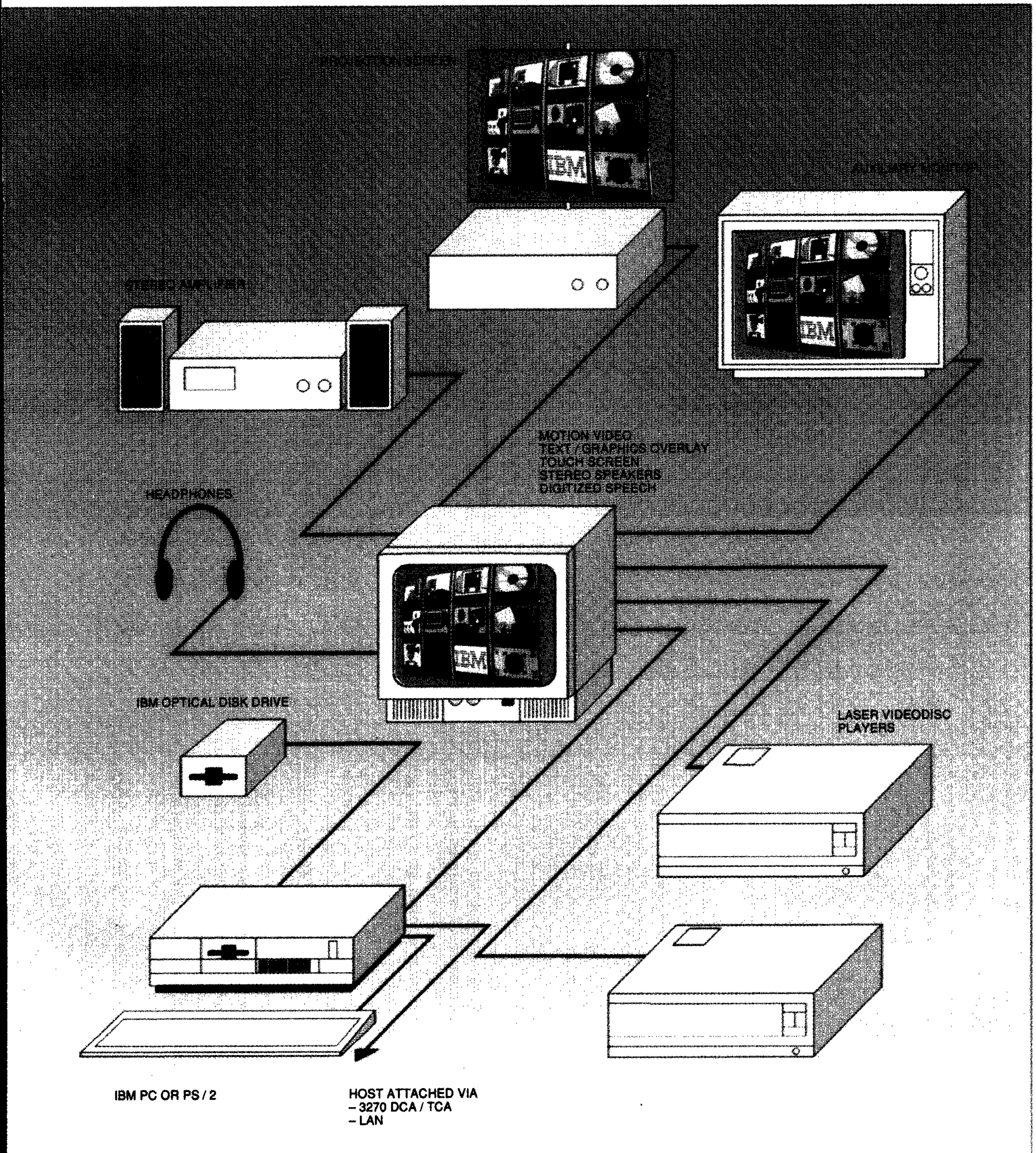


Most multimedia courses provide some form of learner control. These include the standard "hint" and "help" functions, as in computer-assisted instruction, along with a variety of others such as go (proceed to next segment), back (return to previous segment), menu (go to controlling menu), main (go to main menu), clear (clear graphic overlays), bookmark (record midtopic restart point), stop video, start video, replay video, view course map, and exit course.

Generally, these functions are invoked by the student either via touch-sensitive control blocks (called icons) at the bottom of the screen or via the keyboard. Many courses avoid having the icons continually on the screen by using one icon or a keystroke to invoke the others.

Use of the touch-sensitive screen for input. From a media basis, it is not surprising that implementation of touch-sensitive screens was a concomitant feature of interactive video. McLuhan said ". . . TV is, above all, an extension of the sense of touch . . . "[2] On a pragmatic basis, it was probably the application partner of multimedia—product information (or, more specifically, product in-

Figure 3 IBM 4055 InfoWindow system with additional devices attached



formation in a public access area)—that provided the strongest requirement for this method of input. Keyboards do not fare well in public-access environments. Generally, specialized keyboards must be used, and keyboards are not appreciated by those without typing skills.

Many multimedia courses accept either touch-screen or keyboard input from the student.

Increased use of simulation and problem-solving modes. Two CAI-derived learning modes, simulation and problem-solving, are well-suited to interactive video, particularly when realistic motion is required. For example, the Critical Care Curriculum of Intelligent Images[3] uses emergency room scenarios to train medical personnel on how to handle critical cases. The primary medium is actually the patient's chart through which a doctor specifies the action required; the selections may result in a video segment showing the performance of the action (such as the insertion of a nasogastric tube). As in a real-life situation, the doctor is working against the clock.

An authoring system is a program used to create a CAI or CMI or multimedia course.

An example of a personal development course containing simulation is "Management in a Team Environment," used for IBM internal education. In this course, vignettes of meetings are shown, followed by an explanation of the action occurring.

An example of realistic motion used in a completely different type of simulation and problem-solving is the general chemistry course developed at the University of Illinois.[4] The "interactive video chemistry lab" is in use at Illinois and several other universities. The student controls the performing of experiments by directing, for example, compound mixing. On a practical basis, the interactive video laboratory at the University of Illinois is open to students many more hours than the actual chemistry laboratory, and mistakes in this learning environment cannot cause anyone physical harm.

If the subject of a course is a computer-based application, authors have the option of either simulating the application or giving assignments using the actual application. Courses used in the project with the California State University at Fullerton gave assignments using the actual Lotus 1-2-3™, dBase III™, and WordPerfect™ 5.0 applications. A similar approach, known as concurrent training, involves executing the application being taught while under control of a presentation system.

Authoring and presentation systems as media managers. An authoring system is a program used to create a CAI or CMI or multimedia course; a presentation system is the associated component of the authoring system used to deliver the course (i.e., a run-time system).

Authoring systems have been traditionally aimed at persons variously known as course authors, instructional developers, education specialists, and course designers: i.e., a person who knows how to teach. CAI and CMI authoring systems generally sought to provide developers with relief from the intricacies of computer programming, the ability to organize a course, the ability to be a better artist, the ability to analyze a wide range of responses from the student, the ability to simulate a data processing application being taught, and the ability to measure the effectiveness of a course. Often, providing these functions was accompanied by unwelcome restrictions on the developers.

With multimedia instruction came a new emphasis for authoring systems: managing the integration of various media such as video motion, video stills, text, graphics, analog audio, digitized audio (e.g., from CD-ROM), touch-screen input, keyboard, and mouse input. Multimedia authoring systems had to be more flexible than their CAI and CMI predecessors, both from a development standpoint and in providing student options (see previous subsection on increased learner control).

The design of authoring systems must not only be flexible enough to integrate generic computing advances but must continue to accommodate developers at various programming-skill levels. For example, IBM's Learning System/1 (LS/1), like several other authoring and presentation systems, functions at three levels: authors can interact with the system at the menu or prompt level; they can implement other functions through the language extension level; and they can specify exits to routines developed in other languages.

An example of the integration of new function into the media-managing capability of authoring systems is the IBM Audio Visual Connection™ (AVC™).[5] It is actually a combination of adapter cards and software aimed at facilitating creation of a multimedia presentation. AVC enables the developer to capture and digitize audio and video, create music through the Musical Instrument Digital Interface (MIDI), perform image editing, integrate various media into a presentation that can accommodate touch-screen or keyboard input, deliver the presentation via a PS/2 computer using Micro Channel architecture, or, if desired, transmit the presentation to a video cassette recorder or television monitor for video playback.

Integration of multimedia into the standard education curriculum

Despite the very attractive capabilities of multimedia technology, authoring systems to implement these capabilities, and the widespread availability of generic courseware, integration of multimedia instruction into so-called standard education curricula, in both industrial training and academic education, has been slower than expected. This situation remains true even though a growing number of studies show multimedia instruction to be superior to traditional instruction. In addition, students invariably give high approval ratings to multimedia courses.

Startup and development costs are generally considered to be higher for multimedia instruction than for traditional instruction. Yet this does not account for the slow pace in integrating existing courses into standard education curricula. Availability of courses does not seem to be the cause of the problem either. Over 600 generic courses, across a wide range of disciplines, were developed for the InfoWindow system. This list includes only generic courses that are actively marketed. Numerous other generic courses not actively marketed, as well as custom courses, have also been developed.

The degree of integration of multimedia instruction into a standard education curriculum may depend primarily on the attitudes of the groups providing and receiving the education. Because needs and attitudes can vary greatly, Applied Learning International (ALI), of Naperville, Illinois, offers a wide range of generic multimedia courses and a flexible marketing approach. Customers can either lease or purchase courseware, and, if desired, can obtain the multimedia delivery system from ALI as well.

Integration of multimedia instruction into standard education curricula has been slower than expected.

IBM provides most of its multimedia internal education through learning centers. There are at present 607 of these learning centers throughout the United States. Yet the percentage of overall education provided by individualized instruction varies widely by organization. For example, in the National Service Division, which provides service on IBM products and programs, individualized instruction accounts for 33 percent of its total education. For a typical development laboratory or manufacturing plant, the amount is around 10 percent.

Within IBM, the most successful individualized instruction programs have been those defined in relation to traditional instruction—that is, individualized instruction courses that served as prerequisites for traditional instruction courses, or individualized instruction courses that existed because the one-time number of people necessary for traditional instruction classes could not be attained. In universities, individualized-instruction courses, when used, tend to exist more as exercises or as subsets of traditional instruction courses.

The learning center may serve as a transition point between traditional instruction and individualized instruction in the home or office. In other words, before we can free the learner from the limitations of time and place (the goal of Sidney L. Pressey, inventor of the original teaching machine), we may have to settle for just freeing the learner from the limitations of time. In order to achieve full integration into educational curricula, multimedia courses may also have to be perceived as unequivocally superior to their traditional-instruction counterparts.

The jointly defined effort between IBM and CSUF

In the fall of 1988, IBM entered into a jointly defined effort with the California State University at Fullerton (CSUF) aimed at exploring the ways in which interactive video could be integrated into the standard university curriculum. Previous projects with universities had produced some highly innovative materials of excellent quality. However, development time tended to be slow and was increased by the switch from an unannounced InfoWindow precursor to the current product. Most of the courses in these projects had not achieved widespread utilization.

In most colleges and universities the lecture method is the customary and preferred instructional mode.

IBM's objective in the project with CSUF was to see if a parallel approach in course development and course implementation would be more beneficial than the usual serial approach. Under the parallel approach, delivery of generic courses in a learning center would occur at the same time "repurposed" and completely new courses were being developed. Repurposed courses use an existing generic videodisc with the developers' own programs.

IBM was also interested in getting more information on the cost of developing interactive video applications. Average cost of these applications can range from about $60,000 to $1,000,000; the perceived cost is often near the high end of the range. Therefore, a key question was, could a quality interactive video program be developed at a cost near or below the low end?

Environment at CSUF. IBM's objectives seemed compatible with those of a team of professors at CSUF looking at new technology-based modes of instruction.

CSUF, located in Orange County, California, is one of 20 universities in the California State University system. With an enrollment of about 25 000 students and a faculty of 650, CSUF offers undergraduate and graduate programs that span a variety of post-secondary disciplines. The team felt that interactive video had already proved to be a powerful and cost-effective instructional tool. Despite this assurance, there were a number of problems encountered in attempting to promote interactive video instruction at such a traditional university as CSUF.

In most colleges and universities the lecture method is the customary and preferred instructional mode. There are a number of reasons why this mode is retained. Instructors are not sure how to integrate new technologies into tried-and-true methods. Budgetary considerations often preclude expenditures on instructional technology, even when it has proved to be effective. In addition, implementation of technology-dependent individualized environments usually requires substantial allocation of space—a scarce resource on most campuses.

The courseware area lacks a critical mass of reasonably-priced, off-the-shelf instructional material that has been designed for existing curricula. New instructional material is difficult to design and implement; it demands a large investment of time and also requires an understanding of somewhat complex technical subjects. Another problem is that development of innovative approaches to learning is rarely rewarded in the tenure and promotion cycle for faculty.

Any one of the above issues can become a significant roadblock to initiating a successful multimedia project. Consequently, it was decided that any new multimedia project should be melded into existing curricula, possibly with instructional activities. In doing so, the benefits of multimedia had to be demonstrated in as broad an interdisciplinary manner as possible.

When IBM and CSUF began talking about the parallel approach to course development and course delivery, CSUF was already considering whether to establish a learning center. The university had purchased four 4055 InfoWindow systems and had undertaken the following three projects to illustrate the interdisciplinary viability of interactive video:

1. Conversational German—This course, developed by the Department of Foreign Languages, used a generic videodisc originally filmed in Germany by the Defense Department Language Institute.
2. The Authoring/Presentation System (TAPS)—This project, undertaken by the School of Business, involved creation of an easy-to-use system for transporting interactive video into the lecture or classroom environment.
3. The CSUF Directory—This project, also undertaken by the School of Business, showed how interactive video could be used in such campus promotion activities as student recruitment, outreach programs, community service, extended education, etc.

Launching the learning center. The decision to establish a multidisciplinary learning center provided two immediate and significant problems, funding and location. The lack of a single-department sponsor presented funding difficulties, and placement of a multidisciplinary center within one particular department seemed inappropriate.

IBM normally provides only a portion of the resources needed for a jointly-defined effort such as this one. However, other hardware and courseware vendors were also quite interested in this effort, and the university obtained funding from vendors to offset two-thirds of the equipment budget. The location problem also reached a most satisfactory resolution when the university decided to establish the learning center in a large room on the main floor of the campus library.

The university favored the IBM 4055 InfoWindow system because it felt that the system had become the *de facto* industry standard for delivery of multimedia instruction. As such, it offered a wide range of generic courseware and a certain comfort level regarding reliability and maintenance. However, budgetary considerations limited the number of workstations for the learning center to 10 and this limit did place some scheduling constraints on the instructional program.

Other issues addressed during the course of the project included selection of the instructional program, operating in an individualized learning environment, minimizing courseware costs, determining learning center operating schedules, semester constraints, student testing, and student attendance. These issues are now discussed.

Instructional programs. The university decided that the learning center would provide instruction to full-time undergraduate students for a pilot study. The delivered instruction would be part of a regular course curriculum, and students would be graded as part of their general academic program.

Establishing a multidisciplinary learning center provided two immediate and significant problems.

The three-credit course selected for the project was entitled, "MS265: Introduction to Information Systems and Programming." The curriculum for this course is composed of three parts: (1) principles of information systems; (2) introductory computer programming; and (3) basic principles of productivity software—a database manager (dBase III+™), a spreadsheet (Lotus 1-2-3), and a word processor (WordPerfect 5.0).

Because this course is prerequisite to the undergraduate business program, 15 sections of this course are usually offered each semester. It was decided that two sections (approximately 35 students per section) would be used for the study.

Another reason for selecting this course was the existence of a large number of commercially-available generic multimedia courses relating to the course topics. It was decided that multimedia

Table 2 Instructional scheduling

Schedule	Group A	Group B	Group C
Period 1	Lotus 1-2-3	dBase III	WordPerfect
Period 2	dBase III	WordPerfect	Lotus 1-2-3
Period 3	WordPerfect	Lotus 1-2-3	dBase III

instruction would replace the lecture and laboratory approach normally used to teach the three productivity software packages.

Individualized learning environment. The material selected for this study was normally taught in a traditional lecture and laboratory mode consisting of regular lectures supplemented by hands-on work in a personal computer laboratory. This time was the first in which the productivity software portion of the course had been taught entirely in an individualized instruction setting.

During their regularly scheduled lecture time, instructors acted as advisors to the students. Along with a graduate assistant, the instructors helped students who were in the learning center at that time.

Individualized instruction provided students with an opportunity not generally available at the university—receiving instruction at times that were convenient to the students.

Minimizing courseware costs. After selecting the generic courseware packages, the university found that budgetary considerations precluded the acquisition of 10 copies of each of the three product packages. Although that strategy would have permitted each software product to be presented on all 10 workstations simultaneously, the approximate total cost of 30 sets of course materials would have been $60,000. Consequently, three copies of each set of materials were acquired for an approximate cost of $18,000.

Students in each of the classes were randomly assigned to one of three groups. Each group received a different instructional sequence in the three packages (see Table 2).

At any one time, three workstations would be devoted to each package. The tenth workstation was set aside as a backup.

Daily operating schedule. A graduate assistant served two main functions in the learning center: providing assistance when so required by students, and providing security for the learning center itself. Project funding limited the amount of time that the learning center could be available. The center was open Monday through Thursday, from 10:00 a.m. to 4:00 p.m., and on Friday from 10:00 a.m. to 1:00 p.m. This schedule, for 10 workstations, limited the total number of student contact hours to a maximum of 270 hours per week.

Semester constraints. Students could proceed at their own pace through the course. However, because the university environment requires that all students complete a course by the end of a semester, students in the study had to finish all of the instruction within a prescribed time frame. The semester was therefore divided into three three-week time periods. Students were required to complete the instruction for each package within each assigned period (see Table 2 for the allocation of time periods).

This plan provided a maximum of 810 workstation hours for each period (three weeks at 270 hours per week). For each of the approximately 70 students in the study, this amount of time allowed approximately 11 and one-half hours of workstation contact time for each package.

The average duration of instruction for each multimedia course, as quoted by the vendor, was about seven hours. This amount implied a safety factor of approximately 67 percent.

The university limited student use of a workstation at any one time to one hour. Multiple short sessions were felt to be more beneficial than fewer, lengthier sessions. This approach also reduced the amount of student waiting time when all workstations were being used. Students were not permitted to reserve workstations.

Student testing. Multiple choice and true or false paper-and-pencil tests were created for each multimedia course. Students were advised to complete the test for each package within one week after finishing the instruction for that package. These test grades partially contributed to students' midterm grades. (Tests and assignments on other curricular material contributed to the balance of the final grade.)

Because students could take their tests at different times during a period, it was possible that information regarding the tests could be passed along to other students. To eliminate this problem, three versions of each test were created and assigned randomly to students. Although it would have been preferable to have the computer administer post-tests in an on-line fashion, there were not enough workstations available for this to be done.

Student attendance. Students were advised that they could attend and use the learning center anytime within each period and during the hours of operation at the center. They did have to complete all instruction and the post-test for the course within each allocated third of a semester. The traditional-instruction classes that normally provided instruction were canceled and replaced by student access to the multimedia facility.

Results of the study: Student reaction. The project began in February 1989 and was completed by the end of the semester in June 1989. On the basis of student performance and student opinion alone, the study was an outstanding success.[6] Post-test results in all three subject areas indicated that students in the two sections of the MS265 course that participated in the study outperformed students in other sections by approximately one-half grade (5 percent).

Student opinion surveys were taken twice during the project, once after the first period and once at the end of the study. Both surveys indicated that students' opinions regarding the course material, the learning center, the nature of their individualized learning experience, and the project in general, were overwhelmingly positive.

Multimedia course development at the university. Multimedia course development did proceed at the university concurrently with the operation of the learning center. Not only were the conversational German course (using a generic videodisc) and campus directory application (using existing video footage) completed, but a new multimedia course, using original video footage, was developed.

The new videodisc is on group decision processes and, ironically, is used not in individualized instruction but in a team environment. The videodisc helps implement a Group Decision Support System in which a video-based human facilitator guides project team members toward reaching a consensus on an assigned task.

The university was determined to demonstrate that quality videodiscs could be produced on a relatively low budget and to dispel the notion that only video "professionals" could produce a quality videodisc. Fear of an amateurish result causes many organizations to shy away from producing their own multimedia, computer-controlled (Level III) videodiscs. Because of the emergence of various "enabling" technologies in the last decade, this fear is becoming unwarranted.

Enabling technologies. Early efforts to develop Level III interactive video applications were hamstrung by the somewhat limited function of available authoring systems. Since then, however, multimedia authoring and presentation systems have become far more prolific and sophisticated.

Despite these computer-related advances, multimedia application development appears to be still hindered by traditional approaches to video production. In the consumer sector, however, a complete range of products now can economically facilitate the development of video and audio for multimedia applications.

Techniques for the production (or "pressing") of videodiscs have also dramatically improved in the last decade. "Check discs" are one example. They are used by developers to preview their application before creating the final videodisc master. Today, in as little as 24 hours after receiving a developer's master video tape, disc manufacturers can provide the developer with a high-quality check disc for previewing a multimedia application.

Video production at the university. The CSUF Instructional Media Center provides both 16-mm film and 1/2-inch videotape production facilities for campus film and tape projects. The media-center services, including original production as well as editing, helped minimize the costs of all videodisc projects. Although most professionals urge the use of 3/4-inch or preferably 1-inch videotape, these facilities were not available on campus. In the particular videodisc applications undertaken by the university, the use of 1/2-inch videotape did not appear to significantly detract from the quality of the final product.

Group decision processes application. With the main exception of shooting new footage, the development of the group decision processes application was in many ways similar to development of the campus directory. To develop both of these applications, it was necessary to design the course, write scripts, plan the video and audio production, program the computer logic, and produce master videodiscs.

Planning and course design were of paramount importance.

In both projects, planning and course design were of paramount importance. Scripting of the group decision processes application demanded a precise definition and clear documentation of each step in the application. The IBM InfoWindow Presentation System (IWPS) was used to write the application. Novices were able to learn to use IWPS and program, debug, and test the group decision processes application in under five months. Using faculty and students, the Instructional Media Center of the university shot approximately 15 minutes of new footage. This footage was later edited to remove material that would not be accessed by the computer program logic.

Recommendations: Low-budget course development. The group decision processes course was produced by the university completely in-house, and by any method of cost calculation was substantially less than the average low end ($60,000) cited previously. The university has developed the following set of recommendations for low-budget multimedia course development:

- Select any one of the planning and design approaches offered in commercially available seminars. These seminars also sensitize a person to the issues, techniques, and obstacles that are encountered in a project such as this.
- Form a project team composed of a project manager, someone with computer expertise, and someone with video production expertise. The project manager can perform one of the other two roles. The project also requires a subject expert, but this role can also be performed by one of the team members.
- Make the project manager responsible for defining the activities and schedule of the project, as well as for maintaining that schedule. The computer specialist should be experienced with the authoring system to be used to program the application. The video production expert should be experienced in using scripts like the one to be used for the project.
- Take a common-sense approach to producing the video. Design an interactive scenario that requires as few actors as possible; select a setting that does not require shooting in an exotic location; and write a script. All team members should participate in revising the script as often as necessary. When the project team agrees that the script is complete, begin programming the computer logic in preparation for the availability of the video, shoot the video, edit the video, create a check disc, test the disc in conjunction with the computer programs, and be prepared to be disappointed.
- Correct the unavoidable errors with which the first low-budget production is apt to be riddled. However, many of those can be corrected by clever computer programming. Some video errors can be masked by changing the script to display text or graphics rather than the intended video. In such cases, if the video is unacceptable but the audio is okay, play the audio as a narrative over computer-generated text or graphics. If the audio is unacceptable but the video is okay, display the video and use overlaid text or graphics to convey the message required.
- Be prepared to redo the production because even with such clever machinations as just mentioned, aspects of the final product are not apt to meet original expectations. If the project is very important, it may be necessary to reshoot one or more sections of the audio, the video, or both, and re-edit and reassemble the master tape. If a decision is made to reshoot, examine all aspects of the check disc that was created. With only a little extra work, the next generation of the project could be excellent and a candidate for producing a true master disc, depending on the budget and the aspirations of the project.

Significance of the jointly defined effort. The IBM–CSUF jointly defined effort clearly indicates that: (1) the parallel course-development and course-implementation approach, involving development of new or repurposed courseware concurrently with delivery of generic courses at a learning center, can promote the integration of multimedia into a standard education curriculum; (2) in terms of student achievement and student opinion, multimedia instruction can be superior to traditional instruction; and (3) quality multimedia applications can be developed on an extremely low budget.

The projects suggest the effectiveness of an evolutionary approach in which multimedia supports and supplements the primary education delivery approach, which is lecture and laboratory. This same philosophy has been effective in IBM's own internal education.

Hypermedia

The principles of integration, compaction, and increased learner control are also evident in the evolving area of hypermedia. One way to visualize the goal of hypermedia is to picture different authors being able to create materials by accessing and linking any items in the collections of various libraries, whether those items be text, pictures, videos, or audio recordings. These authors can create distinct paths through materials, create and integrate their own new materials, and review materials created by others. They may at one point be the authors of new materials and then be users of materials created by others.

Such a system would significantly integrate and compact, both physically and chronologically, the time-consuming process of scholarly research. However, the basic ability to simply link and juxtapose materials provides significant educational benefits as well. The ultimate success of hypermedia systems depends on electronic storage of collections of materials, in the form of text, image, and digitized recording, along with the development of tools for easily and consistently accessing and linking items in these collections.

One advanced project addressing these problems is the Intermedia system being developed at Brown University.[7] This project uses technology from Apple Computer Corporation, IBM, and Sun Microsystems, along with applications developed at Brown. Another significant step in this area is the joint development of specifications by IBM and Microsoft Corporation to allow developers to more easily create multimedia applications that run on Operating System/2® and on the IBM PC Disk Operating System (DOS) with the Microsoft Windows® program. The specifications include: a resource interchange file format, which allows audio, image, animation, and other multimedia elements to be stored in a common format, and a media control interface, providing a consistent way to control media devices such as CD-ROMs and video playback units.

Hypermedia may be integrated into academic environments far more easily than PI-evolved multimedia instruction.

Hypermedia may be integrated into academic environments far more easily than PI-evolved multimedia instruction. This may be because of the compatibility of hypermedia with explicit and implicit instructor-defined objectives and student-defined objectives; many consider the explicit, author-defined, student-accomplishment objectives characteristic of PI-evolved multimedia to be more appropriate for "training." Regardless of an individual's inclination in objectives, hypermedia and PI-evolved multimedia are compatible, and one can exist within the other. There will be a continuing integration of both approaches.

The direction of individualized instruction

IBM's Corporate Education department defines some eight necessary attributes for internal education in the year 2000:[8]

1. Distributed—Education must be self-directed and accessible on demand.
2. Modular—In general, education packages address a single skill, in contrast to courses addressing multiple skills.

3. Multisensory—Education stimulates sight, hearing, and touch in a variety of ways.
4. Portable—Education is easily moved with the employee.
5. Interruptible—The student can stop and start easily.
6. Nonlinear—There is no fixed sequence of modules.
7. Transferable—Movement is easy across languages and cultures.
8. Responsive—Development cycle is short.

In this environment, much of the responsibility for fulfilling educational duties shifts from management to the members of a team. There is also a good deal of human interaction among electronic classmates (i.e., a group of learners studying the same skills, but not meeting at the same physical place, or even at the same time), between students and consultants, and between students and advisors.

Another form of digitized full motion is animation.

This environment projects achievement of several levels of integration. Not only has individualized instruction been fully integrated into the standard educational curriculum, but it has become the dominant approach, including within it many characteristics of lecture and laboratory. Furthermore, education becomes integrated with, and, in some cases, indiscernible from ordinary work activities.

This scenario requires the use of technologies from the areas of networking and expert systems, as well as advances in the creation of full-motion visual sequences. The most promising path to the latter involves digitization. Digitization of visual images not only allows them to be shown on a standard personal computer display but allows a developer to perform controlling functions such as isolating segments of the image, shrinking, expanding, and windowing. Digital Video Interactive (DVI) is a technique that embraces converting analog motion video to digital form, compressing the video so that it can be stored within a computer, and in real time, decompressing and displaying the video on a computer display. IBM and Intel Corporation jointly market DVI technology as ActionMedia™ 750.

Another form of digitized full motion is animation. Computer-based animation uses programming rather than photography to provide motion. Animation is moving steadily closer to providing the realism of video images and has the advantage of giving the developer control of component portions of the image.

Over the next 10 years, from a development standpoint, DVI and animation will act to integrate the production of full-motion visuals into multimedia systems. On the presentation side, hypermedia capabilities will facilitate accessing and linking a wide range of sources to allow for fulfillment of student-defined objectives.

To IBM's list of attributes for education in the year 2000, we would add two: the education must be engrossing, and it should be enjoyable. At IBM's Boulder, Colorado, laboratory, Phil Smith, who in 1978 invented the prototype of the 4055 InfoWindow system with Doug Winter of IBM Atlanta's Multimedia Solutions, now manages development of a product called the Personal Science Laboratory. This product enables students to perform scientific and mathematical experiments with a personal computer and visualize the results on the display screen.

Low-cost instructional applications such as the Personal Science Laboratory and the "Mammals" program extend the number of environments in which multimedia instruction can be delivered. Although individualized instruction will continue to evolve through the learning center and the office, the most significant hybridization of the next decade may involve computers and the consumer industry. It does not seem like such a large leap from today's video games to the simulated exploration of the world of quantum particles. The technology for, say, viewing a Shakespearean play for enjoyment, and then freezing individual scenes and juxtaposing critical and analytical text beside those scenes, has been around for some time now. We may not be that far from an environment in which the average person looks forward to and really enjoys a few hours of evening education.

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Cited references

1. D. H. Bullock, "Programmed Instruction," D. G. Langdon, Editor, *The Instructional Design Library*, Educational Technology Publications, Englewood Cliffs, NJ (1978).
2. M. McLuhan, *Understanding Media*, Signet Books, New York (1964).
3. *Emergency/Critical Care Series*, multimedia course developed by Intelligent Images, a division of Da Rox Corp, San Diego, CA; available from IBM branch offices.
4. *Comprehensive Chemistry Curriculum and Exploring Chemistry*, multimedia course developed at the University of Illinois; available from IBM branch offices.
5. D. J. Moore, "Multimedia Presentation Development Using the Audio Visual Connection," *IBM Systems Journal* **29**, No. 4, 494–508 (1990).
6. S. Reisman, *Videodisc in the Undergraduate Business Curriculum*, paper presented at the Annual SALT Meeting, Orlando, FL (February 1990).
7. N. Yankelovich, K. E. Smith, L. N. Garrett, and N. Meyrowitz, "Issues in Designing a Hypermedia Document System," S. Ambron and K. Hooper, Editors, *Interactive Media*, Microsoft Press, Redmond, WA (1988).
8. *A Vision of IBM Human Resource Performance in the Year 2000*, prepared by IBM Corporate Education, IBM Corporation, Armonk, NY (January 1990).

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