Putting Education in the Picture[1]

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Abstract

Dissemination of quality content and best practices in education increasingly includes the use of electronic media in lieu of textbooks or direct student-teacher interaction. Several NSF-supported projects are using enhanced and supplemented video to attract a broader student audience to science and to enhance the experience of existing science, technology, engineering and mathematics majors.

The use of film and video as educational programming has come a long way in the past four decades—from an 8-mm projector or a grainy black-and-white television wheeled into the school auditorium to today's interactive CD-ROMs and video-conferencing software. To paraphrase Bill Kurtis, former CBS news anchor and producer of *The New Explorers*, when television first appeared it was seen as the "universal answer" to improved teaching. The usual technique in the 1950s was to record a master teacher giving a lesson and then broadcast the program to large numbers of students in an attempt to raise aggregate learning benefits. When student test scores failed to improve, a kind of technological backlash resulted, with many concerned educators asserting that TV was not demonstrably more effective than a supportive teacher-student interaction (Kurtis, 1996).

In the traditional sense, an effective educational program was viewed as one that told a story with a clearly defined beginning, middle and end. The "hook," or mystery, first attracts the viewer but retention requires a sequential progression so that the audience can (and is encouraged to) logically follow what happens. In telling the story linearly, one has an ideal organizational device to deliver information and, hopefully, a reduced number of competing distractions. Following such a model, the scientific process would be to observe a problem, hypothesize about it, test it by experimentation (or observation), and, finally, resolve it.

According to others, complex subject matter does not lend itself to such storyboarding and today's "sophisticated" audiences are easily bored by a long, methodical set-up or resolution. They have come to expect barrages of information and are not as easily entertained by formulaic plots or predictable twists. In short, viewers have become jaded to the content being presented and more susceptible to the reaction (particularly indifference) of others in the audience. To address this latter point, we might add the stipulation that viewing groups are ideally kept small and that individual viewers should be prompted to react at least every few minutes—in other words, a focus-group model applied to information conveyance. To retain viewer interest, many programs take this method to the extreme, reverting to a music-video-inspired format, presenting incongruous and rapid-fire images, or allowing almost random, point-and-click paths of discovery that challenge the audience to "make sense of this." Granted, scientific observation often involves making sense of an assemblage of disparate facts rather than simply being guided along a narrated path of discovery. However, traditionalists may (and do) argue: Is such a drastic, nonlinear approach prudent for engendering the kind of fundamental inquiry processes necessary for science?

Today's most polished and expensive productions may be slicker in appearance and carry a catchy soundtrack, but the process of broadcast education is still innately subject to technical miscues. An image on the screen merely replicates the dullest of lectures unless the presentation can tell a story and engage the audience in the lesson being presented. Indeed, many video- and multimedia-based lectures have found students' favor as alternate or supplemental means of instruction, but at the same time may give the impression of the instructor being inaccessible when used as the primary means of presentation (comparable to the findings of, for example, Ostiguy and Haffer, 2001). Questions of the effectiveness of video or multimedia instruction seems almost endemic to their use (see, for example, Hinerman, 1991; Michael and Brinkhorst, 1991; and Ducas, 1993), but Allen (1998), Kumar (1990), Wegner, Halloway, and Garton (1999), Urven et al. (2000), and Ostiguy and Haffer (2001) do offer sensible analyses to consider more broadly.

Administered within the National Science Foundation's Directorate for Education and Human Resources (NSF/EHR), the Division of Undergraduate Education (DUE) and Division of Human Resource Development (HRD) support many exemplary projects that use video, film and computer-enhanced animation to improve teaching methods and, accordingly, learning outcomes. Details of the projects summarized in Table 1 can be obtained by visiting the NSF web site (www.nsf.gov) and searching online project abstracts using the award number indicated.

NSF's mission in education includes the recognition and support of exemplary projects and the widespread dissemination of best practices through enhanced communication and reproducible models (see Fortenberry, Powlik, and Baker, 2001). Projects funded by the Directorate for Education and Human Resources support techniques and technologies that enhance the capabilities and effectiveness of teachers and faculty at all academic levels. Events such as NSF's 1996 workshop on information technology and the 1998 NSF and National Academy of Sci-

[1] The views expressed by the authors do not necessarily reflect the policies or opinions of the National Science Foundation, its agents, or award recipients.

ences meetings on the potential for digital libraries extended and refined community support for these objectives (see NRC, 1998; NSF, 1998a, 1998b, 1999). Today, NSF's National Science, Mathematics, Engineering, and Technology Education Digital Library (NSDL) initiative represents a culmination of dozens of national dialogues on the subject of technology in teaching and an investment in taking current prospects to the next level.

A cogent discussion of all popular recording media and presentation devices—past, present, and future—is beyond the scope of the current paper. However, the traditional notions of "film" or "video" did not long remain unaltered in the classroom. Real-time television broadcasts and fragile, quickly fading filmstrips were replaced by the convenience of Betamax and VHS-format videocassettes and, briefly, laser disks. Befitting any widely adopted technology, these new media allowed plug-and-play convenience of a cassette or cartridge in a standard and easy-to-operate player reasonably available to most audiences. At the same time, quality, documentary-style film or video programming as it was known a decade or two ago was prohibitively expensive for most education systems to produce independently. The result was a limited number of stock programs distributed by a few agencies that were not so different from the 1950s newsreels they were in-

Award # (Division)	Institution	Approach	Note
Chemistry			
9354453 (DUE)	California Institute of Technology	Computer animation/ Enhanced	Depiction of molecular orbitals, polymer structure, stereochemistry, and crystal structure, disseminated on videotapes, computer disks, and laser disks.
9455747 (DUE)	Oakland University (CA)	Computer animation/ Enhanced	Multimedia showing the interrelationships of chemical species and phenomena, which are largely omitted from traditional, lecture-style presentation.
Engineering			
9354440 (DUE)	Pennsylvania State University-University Park	Instructional video/ Supplemented	Two courses on ceramic materials synthesis including a master lecture with call-in periods for students. Provides expertise in a specialized subject; continuing-education resources for faculty tutors.
9455761 (DUE)	Film Arts Foundation (CA)	Instructional video/ Enhanced	The two-part "Silicon Run" series, which introduces students to the processes of semiconductor and computer manufacturing (updated in 1997).
9752199 (DUE)	Stanford University	CD-ROM/ Enhanced Supplemented Transcending	Interactive modules designed by instructors, researchers, and textbook authors at several campuses nationwide to enhance student problem solving, intuition, and retention using visualizations, computational simulations, and exercises.
9950514 (DUE)	Auburn University (AL)	Enhanced Supplemented Transcending	Case-study methodology demonstrating the links between course materials and real-world examples. Synchronous and asynchronous multimedia are used in engineering, science and business courses and for teacher preparation. The courseware is also evaluated using an outcomes-based model.

Table 1: NSF-supported projects variously using "moving pictures" to increase student conceptualization and comprehension in course materials. Projects are listed alphabetically by discipline or subject area and chronologically by award number. See Figure 1 and text (pages 14-15) for description of approach. Details on each project may be browsed by award number at www.nsf.gov.

tended to replace. While videocassettes are still widely in use, they have increasingly cheaper, smaller, and often higher-resolution competition from CD-ROMs, DVDs, and streaming video on the Internet. At the same time, the majority of independent production efforts now focus on short animations or demonstrative vignettes rather than costly, full-length narratives.

Concurrent with this mix-and match of presentation media and program styles has been the attempt to combine presentation devices.[2] Certainly the convenience of combining various media players in one unit is something that has gone on since at least the first turntable with a built-in 8-track cassette deck came to market. But as the content of audio and video programming has become more concentrated or demanding of interactivity on the part of the audience, the convenience of a presentation device solely as a player or projector is no longer enough. This observation is particularly apt in the presentation of multimedia-enhanced video. In recent years there have been enticing claims made by the makers of PC-based television tuners, or, alternatively, presentation of Web-based content through one's television. What the purveyors of these technologies ignore is that the convergence of PC and television is at best an awkward fit. In an *entertainment* sense, the "screen" of a computer and the "screen" of a television or movie

0089060 (DUE)	University of Colorado Boulder	CD-ROM/ Enhanced Supplemented Transcending	Multimedia resource center presents instructional modules incorporating text, figures, software, and animation to introduce and attract students to the area of optoelectric microsystems. The materials are used for study and career choices and include distance-learning evaluation.
Geosciences			
9455300 (DUE)	State University of New York Buffalo	Computer animation, instructional video/ Enhanced	Multimedia-based laboratories that develop data gathering skills, data analysis, computer modeling, and simulation of complex phenomena, and illustrate the relevance of scientific skills in society.
9455417 (DUE)	George Washington University (MO)	Computer animation/ Supplemented	A dynamic, highly illustrated presentation of the process and propagation of earthquakes assists students' understanding of earthquakes and other complex geological phenomena.
Life Sciences			
9055563 and others (DUE)	Temple University	Film/ Supplemented	Educational practices for incorporating science fiction films into the teaching of science includes instructional methods and a handbook (see also Dubeck and Tatlow, 1998).
9354599 (DUE)	Sigma Xi Research Society (NC)	Computer animation, multimedia/ Enhanced	Team-based case studies that integrate computer networking and visualization technology, illustrating complex principles and their interrelationships and fostering an appreciation for scientific inquiry and presentation, irrespective of major.
9455324 (DUE)	Cornell University	Computer animation/ Enhanced	Personalized, interactive tutorials in introductory biochemistry and macromolecular structure that counteract the indiscriminate presentation of large, introductory-level lectures.
9551531 (DUE)	University of Massachusetts at Amherst	Computer animation/ Enhanced	Molecular genetics tutor visually depicts the interrelationships and experimental basis for genetic principles to aid student comprehension.

Table 1 (continued)

[2] *Presentation devices* here may be taken to mean, equivalently, the techniques for presenting material as well as the equipment used to project or broadcast the material.

projector are fundamentally different in the kind of engagement they provide: the former is an immersive experience, directed by individual, interactive choices; the latter is more group oriented, with fewer demands placed on the individual viewer. No one wants to read their e-newspaper from across the room or have someone else to do their point-and-clicking any more than one would want to watch a miniaturized depiction of *Gone with the Wind*, *Terminator 2*, or the Super Bowl from a distance of 18 inches. Engaging, individualized *learning*, however, is readily achieved by presenting enhanced or supplemented, controllable video on a computer screen.

With such caveats in mind, let us now address the ways in which many of today's uses of moving pictures[3] in the classroom have learned from the lessons of the past and moved the premise and promise of "educational television" so much closer to the idealized expectations of a half-century ago.

Moving Pictures. All communication is achieved by presenting information of interest to the listener. In the specific case of scientific or technical content, the use of moving pictures greatly foreshortens the conceptualization of what is being presented but does little to establish context. Whether establishing this relevance by moving from the abstract to the concrete, the lofty to the fundamental, or the distant to the personal, the relevance of

9553680 (DUE)	University of Alaska Southeast–Sitka	Video conferencing/ Transcending	Distance-delivery curriculum prepares secondary and post-secondary school students for careers and technicianships.
9752028 (DUE)	Monterey Peninsula College (CA)	Film/ Transcending	Field excursions with crews from IMAX™ and National Geographic give students hands-on experience in science presentation and documentation.
Physics			
9354472 (DUE)	University of Illinois-Urbana Champaign	Multimedia/ Supplemented	Video clips, computer lessons and questions about physics demonstrations guide students' discovery and tests conceptual understanding.
9455740 (DUE)	University of Oklahoma	Video/ Enhanced	Video expositions of electronic computing, entertainment, and medical devices make abstract concepts tangible and relevant to complement lectures.
Science Education and Classroom Equity			
0085834 (DUE)	Carnegie Mellon University	Video image management/ Supplemented	Tools to facilitate the management and indexing of digital-library video content.
9252943 (HRD)	Oregon Graduate Institute of Science and Technology	Mediated communication/ Enhanced	Techniques comparing face-to-face communication with audio-only and audio-plus-video will evaluate the use of new techniques for measuring the effectiveness of interactive technologies including teleconferencing systems, multimedia computing systems, and workstation elements.
9450369 (HRD)	Salish Kootenai College (MN)	Video/ Supplemented	Monthly print materials, telecommunications, and videotapes showing successful practices of the All-Nations Alliance, which includes 24 participating tribal colleges.
9552986 (HRD)	National Coalition of Girls Schools (MA)	Multimedia/ Supplemented	Professional development tools for precollege teachers including successful approaches to the use of technology in elementary/secondary instruction.

Table 1 (continued)

[3] We use the term *moving pictures* here not as a quaintly old-fashioned allusion but as a generic reference to animation, video, and film, whether analog or digital.

the lesson being presented begins with a relevant story or narrative. The simple presence of a television or movie screen in a classroom can heighten levels of student attentiveness. The sense that "something different" is about to happen begins to ripple through the audience almost immediately. This attentiveness, however, will endure only as long as the programming being presented remains engaging and meaningful to those watching it. Thereafter, the same novelty quickly becomes little more than a convenient distraction from the exchange of student-teacher dialogues. Raised on lushly crafted computer games and expensive music videos, most students might be assumed to have high expectations for the aesthetics of the programming they are asked to watch. However, this is not necessarily so. In the same way that most successful comic strips do not engage readers with especially sophisticated artistry or rapid-fire presentation, in the same way that a $100 million science-fiction movie can flounder at the box office, so too does the quality of the lesson—the take-home message—surpass nearly any presentation medium, from a cramped chalkboard to high-definition TV. In other words, a sufficiently engaging story should be able to attract an audience no matter how it is presented. Realizing this, it is not the instructor's duty to use video, film, or animation only for technology's sake, but to identify what it is about video

9553325 (HRD)	The University of Northern Iowa	Video/ Transcending	Demonstrations for teachers and teacher educators to improve their skills, resource base, and assessment strategies in presenting science to students with disabilities.
9553488 (HRD)	Chabot Observatory and Science Center (CA)	Planetarium show/ Enhanced	Original research and a new planetarium program about women's contributions to astronomy will include lessons learned and a teacher-enhancement program to promote dissemination.
9625566 (HRD)	University of Utah	Video/ Transcending	A 30-minute video featuring women in earth-science careers to acquaint young women with new opportunities.
9712964 (HRD)	CAST, Inc. (MA)	Video/ Enhanced	Video-captioning technology aimed at disseminating research findings to schools with deaf as well as hearing students.
9813926 (HRD)	Triad Alliance for Gender Equitable Teaching (CA)	Video/ Supplemented	Handbook and video for teachers seeking to change the gender-equity climate for girls in school class rooms, including *Triad: A Guide to Promoting Gender Equity through Partnership*.
9906123 (HRD)	The Marie H. Katzenbach School for the Deaf (NJ)	Video/ Enhanced	Video-conferencing technology facilitating collaborations from remote locations and increasing the degree of science literacy and interest among deaf and hearing impaired students.
9976086 (HRD)	Georgia Tech Research Corporation	Laboratory experiments/ Enhanced	Computer-access technologies, compact disk and instructional workshops to instruct teachers in the modification of laboratories and laboratory experiments to better engage students with disabilities.
9800324 (HRD)	University of Washington	Video/ Supplemented	Disabilities, Opportunities, Internetworking, and Technology (DO-IT) videos are part of a multi-faceted approach allowing students with disabilities to reach their full potential in career or college preparation.

Table 1 (continued)

(or film, television, computer, or animation) that can enhance the telling of that story in a way no other device comparably can. In the case of moving pictures, this unique, value-added content offers all the immediate "visualization" of illustrations or static photography, but in its use of motion, sound, editing, and narration can also provide conceptualization in the context of a relevant story. A generalized account of the process of lesson through communication is presented in Figure 1.

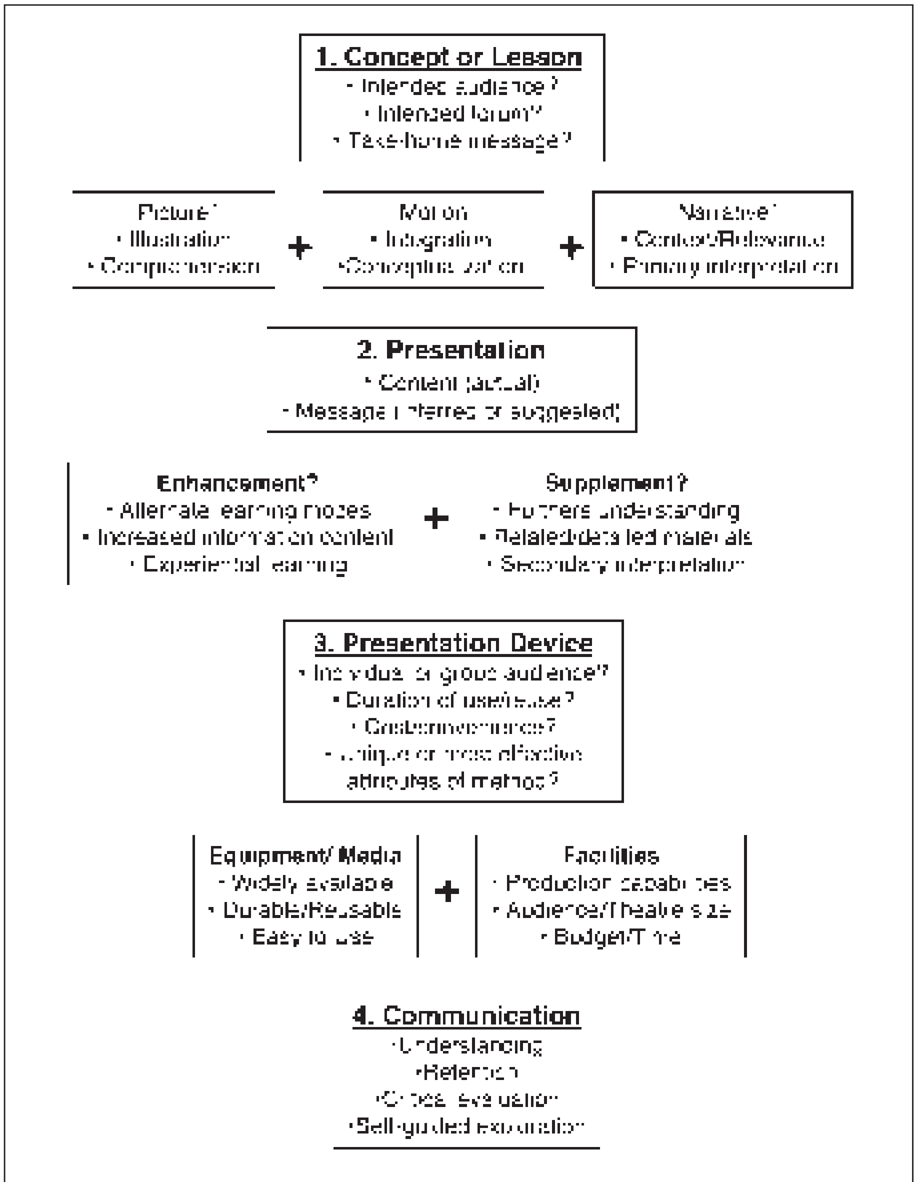

Figure 1: Schematic showing the progression from concept to communication using pictures, text, and narrative with enhanced content and/or supplemental materials. The more of these elements that are considered at each stage of the process, the more effectively the message may be delivered.

Thus, two seemingly conflicting requirements co-exist: to craft a program that sufficiently addresses the Intended Lesson, but to do so with a design or construct that remains modular, generic or nonspecific enough to extend the utility of the program as long as possible. The trade-off in engaging the audience is to accurately present general truths while couching the details in terms and examples that are memorable and relevant at the individual level. In terms of the three overarching considerations—cost, convenience, and personal context—computer-based content, video enhanced by animations, text, and sound revealed by self-guided exploration may seem to have the advantage. But there is still something to be said for the broadcast method of presenting material, offering an entire class the same experience at the same time and proceeding at the discretion of the instructor, akin to any field trip and many lecture formats. Expectedly, the "best" answer for effective presentation is some combination of the two, as the following independent solutions reveal.

Enhanced Moving Pictures. Programming can be enhanced with the addition of content added "inside the box," or within the frame of each moving picture. Video recording and editing devices for the home or business have allowed a renaissance of sorts for program production and presentation. Many larger schools are now equipped with their own media rooms, sufficient for useful (if modest) video productions, image scanning and computer-based editing. With only a slight compromise in quality, the usefulness and dissemination of the video product have been greatly advanced while, secondarily, developing skills in presentation and program development by those doing the work. This technology has radically diversified the various ways in which visual content can be presented and it has increased the ways in which this content can be recorded and enhanced at either the professional or personal desktop level. Computer-generated titling or captioning not only gives the presentation a more polished appearance, it yields a more informative product, conveying information on two or more sensory channels. Not only is the potential audience for the content increased, but in addressing multiple learning mechanisms (image presentation, audio reinforcement, text repetition or some combination of the three), the potential for that content to be registered and remembered by the viewer greatly increases.

Supplemented Moving Pictures. The effectiveness of moving pictures can also be increased "outside the box" of the computer screen or television monitor. Supplemental material may include textbook or workbook exercises that encourage students to pay closer attention to what they are watching, test their understanding of the material, or apply what they have just seen to related examples or problems. Supplemental content may also include links to Internet sites providing more information on key topics and themes or "crossover" products between videotape, print and computer-based media. If overly enhanced presentations run the general risk of allowing the audience to get by with a minimum of interaction or participation, the motivation and engagement of the audience can be greatly facilitated with the appropriate use of quality, well-designed supplemental materials.

Transcending Moving Pictures. Like evocative prose and poetry, the value of a well-presented visual story lies in its ability to stir the theater of the mind. This need not be some frivolous aspiration. Whether it is a travelogue of some exotic land, a journey through an atom, or an interview with a famous personality, the moving picture has the ability to take its audience out of the classroom to another place, whether that place is actually another location, another field of study, or simply another perspective on the world. And unlike the theater of the mind constructed by literature, the instructor can be assured that the moving-picture destination is more-or-less the same place for everyone in the audience. As with enhanced products, devices providing closed-captioning or haptic feedback may help to include students with disabilities in these adventures, but this is not their only benefit. In presenting images in conjunction with audio and visual reinforcement, all students can retain more from the experience. In this way, transcending experiences are particularly relevant in programming seeking to promote gender equity or to better include students with disabilities. The enhanced or supplemented presentation of moving pictures not only puts everyone in the same "picture," but it makes that picture experiential and emotionally moving. Done effectively, it presents the Lesson as Life, but merely showing labels or having "talking heads" recite some kind of expository text is not enough to achieve this goal.

The early caveats and criticisms of "eduTV" are equally valid today, and could readily be extended to our first tentative steps in Internet-based education. The future of distance learning, multimedia educational products, and other electronic teaching aids may still be up for grabs, but assuredly, the use of photographic, computer-generated, filmed or videotaped moving pictures will continue to be an essential component of this progression. From a technical standpoint, authoring tools, imaging software, and graphics packages continue to make the production of advanced education materials easier and more accessible. However, for these same reasons, the role of the teacher in interpreting the best use of this technology has never been more important. Just as in the era of chalkboards and printed texts, the role of presentation technology is more than that of a "class-sitter." The teacher remains essential for locating the best examples from a wealth of substandard data for placing the lesson in the most rewarding context for the student.

Whatever the presentation, images should strive to entertain and engage (as opposed to simply entrance) their audiences, from the product packaging to the lingering, take-home message. In crystallizing the concepts presented—whether concrete or abstract—the student is ideally attracted to the point of voluntary immersion and inspired to continue that journey on their own. This requirement is not so different from that of any effective learning tool. The real challenge in the ages-old debate of teachers-versus-technology is as it has always been: not *which is better* but *what balance of the two is best*?

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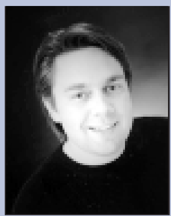

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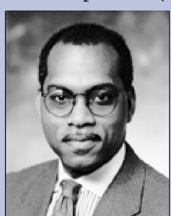

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